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TRAPPERS AND THE FOREST INDUSTRY:

THE CASE OF NORTHWESTERN ONTARIO

Funding Program Report

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J.E.J. FAHLGREN, COMMISSIONER

TRAPPERS AND THE FOREST INDUSTRY:

THE CASE OF NORTHWESTERN ONTARIO

by

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> The danger of complete man-centredness in relation to nature is the danger of immediate and thoughtless selfishness everywhere: the monetary gain results in ultimate loss and defeat. 'Enlightened self interest' requires some consideration for the other fellow, for the other nation, for the other point of view; some giving with the taking.
>
> Marston Bates
> The forest and the sea

SUMMARY AND RECOMMENDATIONS

The forest industry has been harvesting timber in progressively more northern and western areas of Ontario and this trend brings it into increasing contact with trappers. There is disagreement as to the extent of the resource conflict engendered, and as to whether it has a biophysical or a socio-economic basis. This report examines the development of Ontario government policy towards trappers and the forest industry. It examines which vegetation types trappers depend upon in their search for furbearers, and how these habitats change under the influence of fire control and logging. Disruptions in the economy and lifestyle of trappers resulting from forest harvesting are investigated, as well as trappers' feelings towards logging and the government. Policy implications are identified and recommendations for future policy, management and research have been formulated.

A comprehensive government trapping policy was initiated in 1947. In the following years great strides were made towards a holistic style of land management. The 'Fur Advisory Committee' meetings of the Federal and Provincial governments were very important in this regard. They recognized the split jurisdiction between Federal government's concerns with native welfare and the Ontario government's land management mandate. Several participants at the meetings urged integration of wildlife and timber management. These early advances were not maintained because of perceptual difficulties among the majority of participants. The foresters' perception of wildlife showed a narrow professional and cultural bias which limited their

viewpoint to those species significant in timber damage. A parallel bias in the Ontario Ministry of Natural Resources Fish and Wildlife Branch resulted in a tendency to neglect any species that did not fall into a Southern Ontario perception of recreational wildlife. A possible exception was the research and management of beaver (Castor canadensis), but even here other furbearer species were largely excluded, though they collectively represent a large part of the trapper's income. There is virtually no overlap between forestry and wildlife research in the Ministry, and there have been few attempts to use existing tools, such as the Forest Resource Inventory, for holistic land management. Most of these problems stem from lack of effective co-ordination within the Ministry, and this situation has remained virtually unchanged since 1960. There is no current research on the effects of the forest industry on furbearers or trappers.

The field study area is the southern three working circles of the proposed Great Lakes (formerly Reed) logging area in NW Ontario. This area is typical of much of the boreal forest zone in Northern Canada. A time series approach to furbearer changes following logging was not feasible. As an alternative, the forest within selected trapline areas was classified using cluster and discriminant analyses. Data were obtained from forest resource inventories. Nine forest types were recognized and the mix of these in each trapline was compared with the catches of beaver, Fisher (Martes pennanti), Lynx (Lynx canadensis), Marten (Martes americana), Mink (Mustela vison) and Otter (Lutra canadensis), using stepwise multiple regressions.

The results showed that the catch of individual furbearers is correlated with various habitat types, and that the behaviour of the trapper vis-a-vis the terrain and vegetation is almost as important as the habitat of the furbearer itself. Statistical instability of the equations limited their usefulness, however, and a third approach was attempted.

The importance of each vegetation type to each furbearer was assessed through interviews with trappers. This was further weighted according to the relative economic importance of each furbearer species. The analysis showed that the significant habitat types are, in decreasing order of importance, poplar, birch, marshes, alder swamps, bogs, tamarack swamps and black spruce swamps. Some of these, such as poplar and birch, are only significant when associated with nearby water. Both recently logged and recently burned habitats were found to be of very little value to trappers. It was concluded that,at least in the first few years after disturbance, logging and fire are detrimental to trappers.

In predicting future changes in trapping productivity, a modelling approach was adopted in which the landscape is regarded as a population of individual ecosystems of various ages. Observed age distributions show that in the study area the amount of disturbance, principally through fire, has decreased since about 1920, and this is primarily due to fire control. Overall disturbance is now one-third of its original level. The reduction in uplands is to about half of the original rate and, in lowlands, to about one-sixth. Thus the present forest already differs considerably from that which would exist under 'natural' conditions.

Had there been no fire control in upland situations there would be fewer mature fir (Abies balsamea) and white spruce (Picea glauca) stands and a lesser amount of birch (Betula papyrifera). With present fire control to the year 2017 we expect to see a further expansion of fir and white spruce forests and also of black spruce (Picea mariana). There will be a reduction in pioneer stands dominated by aspen (Populus tremuloides) and jack pine (Pinus banksiana). With logging from the present to AD 2017 acreages of jack pine and black spruce will also be reduced, to be largely replaced by poplar and birch.

In the lowland areas, had there been no fire control to the present, one would see a landscape with much less mature black spruce and more treed muskeg. The area of open muskeg would also be nearly twice as large. Further fire control to the year 2017 will result in increases in mature black spruce areas with corresponding reductions in treed and open muskeg. Introduction of logging would result in increases in treed and open muskeg relative to black spruce. In summary, heavy logging will partly restore the original age distribution of the forest, but its composition will have changed relative to the pre-fire control situation. There will be more deciduous and mixed wood stands.

It is estimated that the present furbearer productivity of the landscape is a little lower than without fire control. With further fire control the furbearer productivity will drop a little more but the total decline will only be about 10 per cent. The overall harvest level with logging will also be about 10 per cent below that for the natural forest. The situation for individual traplines will

be much worse, however, since large areas of productive habitat will be replaced by cutovers with minimal furbearer productivity. This is how the principal damage to the trapper's livelihood occurs.

To estimate the socio-economic effects of these changes, 23 Sioux Lookout area trappers were interviewed. Two-thirds of these were natives. They represented a wide spread of age and experience. About half the trappers believed that logging is damaging to their livelihood, and all of those whose areas had been logged thought so. Their attitudes to logging roads were ambivalent because roads provide some benefits such as easier access, but also exacerbate problems like poaching. There were other complex social interactions such as changes in residence and schooling patterns resulting from the presence of roads.

Most trappers regard forest fires as damaging though some believe them to be beneficial in the long run.

When asked about changes in trapping success following logging those who had experience of this (8 trappers in total) cited reductions in marten, fisher and lynx. Several trappers knew of others who had given up trapping or had moved traplines following logging. One trapper in the survey had taken wage labour because of logging damage and another had moved his trapline.

All the trappers surveyed were satisfied with their lifestyle and none preferred any other occupation to trapping. Most, however, had other work in summer. Logging employment did not appear to be absorbing trappers whose lines had been logged, though the reasons for this are not clear. Amongst alternative occupations the most

preferred was logging at a commuter camp while the most disliked were work in pulp mills and mines, and welfare.

Trapping was found to provide tangible benefits not often counted in economic surveys. These include significant amounts of protein food, housing and wood fuel. Five of the twenty-three trappers live entirely in the bush and several more are heavily dependent on countryside resources. It is probable that those who cut back on trapping because of logging damage suffer some decrease in nutritional status.

Most trappers have a negative attitude towards the government and the Ministry of Natural Resources in particular. This results from a lack of consultation on issues such as logging damage, from educational and language differences between government officials and trappers, from illiteracy among some bush dwellers, because trappers are by nature very independent, and because they tend to live in remote places. On the positive side some individual ministry officials do make strong efforts to mitigate the effects of logging and to maintain good relations with trappers.

Ontario government policy clearly gives logging automatic priority over trappers. There has been virtually no recent research or management which recognizes the relationship of trappers with their forest environment and with the forest industry. There is apparently little co-operation within the Ministry of Natural Resources between the Division of Fish and Wildlife and the Division of Forests. Within the Wildlife division the Furbearer branch appears to have fairly low status. Trappers are poorly represented before the

government because they are poorly educated, widely dispersed, and politically unsophisticated. One would have to be extremely optimistic to believe that this situation is likely to change soon.

Policies which might alleviate the problems which trappers face include -

1) Avoidance of logging in areas which are marginal for forestry.
2) Intensified efforts at forest regeneration of logged areas so as to limit the area needed by the forest industry.
3) A more dispersed pattern of logging based on smaller working circles, and smaller logging camps moved more often.
4) A scheme whereby trappers would have the option of logging their own traplines as a summer occupation, thus avoiding the problems of large areas of recently cutover land.

<u>Nine recommendations are made as follows</u> -

1) The Commission should strongly represent the interests of trappers before the Ontario government.
2) The Commission should urge the Ontario Government to issue a clear policy statement on trapping and logging as a basis of Ministry of Natural Resources programs. In particular the statement should clarify whether or not the government wishes trapping to continue within the zone of economic forestry and, if so, whether it will act decisively to ensure that trapping continues.

3) Ministry of Natural Resources officials should begin immediately to consult individual trappers when their traplines are to be logged, so as to avoid unnecessary disruption and damage.

4) The government should encourage more co-operation between the Ministry of Natural Resources Timber Division and the Furbearer Branch of the Wildlife division.

5) The Ministry of Natural Resources Furbearer Branch, in co-operation with the timber branch, should investigate how the effects of logging on trappers can be mitigated.

6) The following measures should be adopted to mitigate the effects of logging on individual trappers -

   a) The MNR should make arrangemements to move those trappers who are willing to new traplines when logging becomes a serious impediment to their work.

   b) Trappers should have the opportunity to work at logging when a logging camp is using their trapline.

   c) Trappers should be compensated for loss of cabins etc. if they have to move traplines as a result of logging.

   d) Logging camps should be kept as small as possible and moved as often as is feasible.

7) The following measures should be adopted to mitigate the effects of logging on trappers in general. They will minimize intrusion of the forest industry into new areas -

a) There should be more intensive forest management in areas close to existing pulp and wood mills.

b) Efforts to regenerate the backlog of poorly reforested cutover areas in Ontario should be continued and intensified.

8) The government should investigate the provision of a general licence which would enable bush-dwellers to integrate their seasonal round of activities. It might include provision for the following activities -

Home making
Trapping
Commercial fishing and minnow fishing
Meat harvesting
Wild ricing
Small-scale logging
Guiding

9) The Ontario government should appraise its policy of keeping all logging roads open to public vehicular traffic wherever possible. Any study should include the biophysical, economic and social consequences of open and closed road policies.

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INTRODUCTION

The logging industry in Ontario is thrusting steadily north and west in its search for new raw materials (Suffling and Michalenko, 1980), and this brings it into increasing contact with trappers who have until now subsisted in a relatively natural forest environment, and in an economy which, although profoundly influenced and changed by the world's industrial system, was nevertheless buffered by its remoteness. The logging industry tends to dominate in this new, intensified relationship because it is more organized, it has more employees and it generates more of the gross provincial product than trapping.

Various opinions exist as to the nature and desirability of the effects of logging on trappers. Most of those in government and the logging industry believe that logging and trapping are largely compatible in a biophysical sense, and that any decline in trapping harvests is the inevitable consequence of changing lifestyles and expectations, coupled with the economics of the international fur market. They believe that there is little to prevent trappers from continuing in their vocation, but if they wish to join the industrial economy and its associated society, this will occur naturally and inevitably.

Other people, notably sociologists and anthropologists, also believe that the most potent effects of logging on trapping are expressed

in social and economic changes which are essentially independent of any habitat change. Many of them are less convinced, however, that the transition to an industrial society is necessarily desirable. Some believe that such changes are inevitable, while others seek a new model for northern rural society.

Some trappers themselves, have expressed grave concern at the preliminary hearings of the Royal Commission on the Northern Environment (RCNE) that logging is damaging to the trappers' habitat, economy and lifestyle. In particular, they expressed the belief that furbearer habitat destruction accompanies logging and that the provincial government has done very little to mitigate or avoid such impacts.

This report assesses the effect of the logging industry on trappers, with particular reference to northwestern Ontario. It addresses the following questions -

- How have government policies developed towards land management involving trapping and/or logging? (Chapter 2)
- What kind of forest habitat is desirable for trapping? (Chapter 3)
- What kinds and amounts of habitat change are to be expected following logging and/or fire control, and how do these changes relate to trapping habitat? (Chapter 4)
- What changes in the economy and lifestyle of trappers occur as a result of logging, and how do trappers feel about such effects? (Chapter 5)
- What are the policy implications of the questions posed above? (Chapter 6)

CHAPTER 2

THE INTEGRATION OF TRAPPING AND FORESTRY IN GOVERNMENT POLICY

2.1 Introduction

A broad range of past and present government documents was scrutinized for issues, problems and policy response relating to the integration of trapping and forestry. This was supplemented by interviews with resource managers.

This analysis is restricted to the period spanning 1947 to the present, because 1947 marks the beginning of the first serious efforts at fur management. In addition, the discussion of policy is subdivided into two distinct eras of management; the period of the Fur Advisory Committee (FAC) from 1947-1960; and the years from 1960 to the present. A brief description of the fur program of 1947 will set the stage for the subsequent policy discussion and analysis.

2.2 The Fur Management Program, 1947

The foundations for Ontario government's fur management program were laid soon after the merger of the Department of Fish and Game and the Department of Lands and Forests in 1946. The Trapline Management Section of the new Fish and Wildlife Division was responsible for developing and administering a trapline management

program for the province.

The following is a brief summary of the program that was developed:

a) All trappers other than farmers were required to have licenses. Three categories of trapper were created. They were the registered trapline licensee, who could only trap in a designated area on crown land; the resident trapper, who could trap in a township or its equivalent area; the farmer trapper, who could trap on his property without a license. These three license categories accommodated the basic differences between northern and southern trappers. The northern trappers, and their ancestors, the majority of whom are natives, had trapped in some areas for more than a century and the revenue obtained through this pursuit represented a substantial part of their income. Southern white trappers formed the majority in the second and third categories. The resident trapper is commonly a part-time trapper supplementing a regular income. Local conservation officers were responsible for distributing licenses and judging the furbearer carrying capacity of a township. In the case of a trapper dying, the trapping area would revert to the crown for equitable distribution to heirs or others as the Department saw fit (Fur Advisory Committee Meetings (FAC), 1947-51, n.p.).

b) Trapping areas were delineated and the boundaries recorded on topographic maps. On applying for a license, trappers were required to sketch their traditional trapping area, showing topographic features and locations of beaver lodges. This information was then used to set quotas. (This became known as the watershed system.) The size of a trapping area varied inversely with the productivity of a region. The district conservation officer was responsible for deciding how large a trapping area would be, and for settling any boundary disputes.

c) Pelts had to be sealed by a Department Officer before they could be sold. Thus, statistics on the number of each species caught could be recorded and it was felt that sealing would reduce illegal traffic in pelts.

d) Harvest quotas were set for most species. Beaver quota was one animal per lodge for the entire province. Other species' quotas were set on a district basis and depended on local population sizes. Beaver quotas were derived from the number of active lodges the trapper recorded in his area. Beaver could be taken from each lodge or the quota spread over a smaller number of lodges. This allowed the trapper partial control in the management of his area.

e) Trapline management officers were appointed to implement the new program, to improve trapper-government relations, to set up trappers' councils, and to inspect traplines.

2.3 The Era of the Fur Advisory Committee, 1947-1960

2.3.1 The Formation of the Fur Advisory Committee (FAC)

Annual meetings between Department of Lands and Forests' field officers and Indian Affairs Branch agents began approximately when the fur management program was introduced. The various problems and issues resulting from the implementation of the program were discussed at these spring meetings so that if any problems arose there would be enough lead time to implement solutions for the next season.

The meetings proved invaluable in enhancing co-operation between the federal and provincial agencies. This was essential for effective fur management because jurisdiction over the resources and over the majority of trappers was split between the two levels of government. The federal government was responsible for the social welfare of the trapper, and the provincial government for furbearers and their habitat. Because these informal meetings were successful, the federal and provincial governments entered a formal agreement to continue co-operation in the form of a Fur Advisory Committee for a ten year period commencing in 1950.

The agreement was to:

a) Aid proper management of the resource to benefit the native (sic.) trapper.

b) To minimize duplication of services and maximize economic efficiency.

The committee meetings, held each spring at several places in northern Ontario, included reports from management officers, reports on

the status of furbearer populations and harvests, discussions of progress in trapper/management relations and the discussion of special projects. During the next ten years, the province's fur management program was, for the most part, developed at these meetings.

2.3.2 Trapping and Forestry Policy Integration During the Fur Advisory Committe Era

The reorganization of wildlife and forest management agencies under one department in 1946 was seen as an improvement in the management of the province's resources, but the agencies remained separate with respect to their duties. The Forestry Division managed timber cutting and forest protection, while the Fish and Wildlife Division supervised wildlife harvesting and protection. Since large scale forest cutting would be the major activity affecting furbearer habitat it was inevitable that the interests of the two divisions would sometimes conflict.

The first indication of interest in co-ordinating activities of the two Divisions occurred at the 1948 FAC meetings (FAC, 1948). For several years most efforts were concentrated on implementing the new management program and improving trapper relations. In 1954, interest integrating fur and timber management was kindled by reports from the Gogama and Chapleau experimental traplines which indicated relationships between fur harvests and timber types (Loucks, FAC, 1954, n.p.).

A paper on beaver ecology (Standfield, FAC, Sudbury, 1955, n.p.), presented at a 1955 meeting of the FAC, sparked considerable discussion on the topic of integrating forest and wildlife management.

This topic was made an important part of the agenda for the following year.

The 1956 meetings showed the greatest interest in the issue of integrating forest and fur management. Many papers were presented on this topic. One presented at Dorset by J. W. Giles, a forester, was entitled, "What'll You Have--Deer, Birch or Both?" (Giles, 1956). As the title suggests, the majority of the paper dealt with deer and yellow birch and not furbearers but the rationale behind the presentation was that it "was an outstanding example of the need for a well planned program of multiple use of forested land" (Giles, 1956, n.p.). Giles pointed out that the responsibility of wildlife and forest management fortunately lay in one government department. "Thus, if integrated programs are indicated, one man only [the district forester] is nominally responsible . . . " Yet he also stated that: "The forester does not worry over the presence of balanced populations of furbearers, game animals, trappers and hunters, in the <u>forest factory</u> he is building . . . " (Giles, 1956, n.p.) [our emphasis].

This candid portrayal of many foresters' narrow perspective leads one to doubt the ability of the District Forester to make unbiased decisions in resolving resource conflicts. Giles also suggested that forest cutting benefits trapping "because fresh habitat is created" and "trappers enjoy abundant fur yields from the young forest" (Giles, 1956, n.p.). In general the presentation suggested that forestry does not pose any problems to wildlife management, and thus that foresters would only be concerned with wildlife if it

threatened timber production. Finally his closing statement that: ". . . fish and wildlife interests can be served satisfactorily by slight modifications to forest management plans by the district forester" (Giles, 1956, n.p.) suggests wildlife management schemes would automatically take a 'back seat' to forest management plans.

At the next meeting, held in Sault Ste. Marie, G. Coyne, the Chapleau District Forester, discussed the basic concepts behind multiple use management, and classified the province into three management areas: the southern farming and industrial belt, the northern barrens and the central forested belt. He went on to describe management scenarios for each area and the possible conflicts that may arise. He made several interesting points about the co-ordination of fur and forestry management, suggesting that the ideal type of forest for a forester is exactly the opposite for a wildlife manager (Coyne, 1956, n.p.). Thus, compromise would often be necessary to achieve an optimum balance of interests. He identified the central forested belt as the area of greatest potential conflict, stating that, ". . . to realize maximum return [in the central forested belt] integrated management must be practiced." But he also pointed out, that in this area of greatest need for co-operation, ". . . there is no co-ordination between game and timber people." This is in strong contrast to J. W. Giles' (1956, n.p.) contention that multiple use management, ". . . is an active program not just a slogan, in Ontario."

Coyne (1956, n.p.) went on to criticize the system of timber management units saying: ". . . they are designed to do just that and no more." And,

> We have gone to considerable thought and expense to plan cutting practices, road locations, regeneration plans, etc. for these units and we are very likely to become so committed to these established boundaries that they will become inflexible and the administration of them will become so channelled with specific personnel devoted to timber management only, that any later changes which may become necessary will be very difficult to inject into the organization.

He also pointed out that it was ". . . very obvious that very little was written into the [timber management] plans . . . " (Coyne, 1956, n.p.) that benefited wildlife.

Coyne argued that habitat is the single most important factor controlling wildlife populations and that timber management was the only economical way of controlling habitat (Coyne, 1956, n.p.). This is an extremely important observation as, in later years, high costs became a popular excuse for not implementing habitat management. Like Giles (1956, n.p.) he underlined the advantage of having all the administrative agencies in one department. In addition, he suggested that there were adequate personnel to implement an integrated management program, but that nothing was being done about it (Coyne, 1956, n.p.).

Coyne's paper provided a critical appraisal of the unintegrated nature of forest and wildlife management. He illustrated the advantages of integration, and showed where changes in the management system should be made to achieve it. He was prophetic in voicing the fear that timber management practices would become entrenched and immutable.

A third paper on integration was presented by J. E. Dickenson at the Port Arthur meeting of 1956. He discussed some modifications to

timber cutting practices for improvement of wildlife habitat and, like Giles (1956, n.p.), he suggested that timber management plans could be slightly modified to consider wildlife (Dickenson, 1956, n.p.). He reasoned that wildlife was secondary to forest management since timber was more important to the economy of the province.

In contrast, Coyne provided an economic argument for integration: ". . . one of the most favourable factors of joint game and timber management is the total utilization of the site with a revenue producing product" (Coyne, 1956, n.p.).

Unfortunately, the collective economic benefits of integrated timber and wildlife management never became a serious topic of discussion. From what had been said so far it was becoming obvious that few would heed Coyne's advice to ". . . cease to think of ourselves as managing one particular phase of the total resource [so that] we can start to integrate the various [resources] and manage them accordingly" (Coyne, 1956, n.p.).

Integration was again the major topic of discussion at the 1957 meetings. G. M. Longley outlined the issues to be discussed. His presentation concentrated on the influences of timber management on wildlife management.

Longley felt that ". . . the onus to instigate co-operation is upon the wildlife managers" and that their plans should be presented in a form that could be "<u>superimposed</u> on the timber plans for [a] particular area" (Longley, 1957, n.p.) [our emphasis]. To <u>superimpose</u> is not to integrate, for this reason we believe this presentation supported the premise that wildlife management was automatically secondary to timber management.

Trapping and its associated species gradually ceased to be mentioned, whereas hunting and game species were more frequently cited (trapping was not referred to at all in Longley's paper). This, we believe, resulted from the diversification of interest occurring in the last half of the FAC era. This development is significant as it generally weakened the efforts for integration. Firstly, there were fewer game species than furbearers, thus fewer potential conflicts with forestry could be perceived. Secondly, important game such as moose and deer have largely benefited from forest cutting, this would tend to downplay any adverse impacts on other wildlife including furbearers.

Integration was discussed for the last time at the 1958 meetings. The major ideas presented over the last few years were summarized by W. M. Bastedo, a district forester. Again, furbearers were not mentioned, and it was apparent that forestry had automatic priority in policy formulation. He said: "In northern Ontario at least timber, <u>recreational</u> fish and wildlife are the major considerations with timber interests, perhaps, dictating the major policies" (Bastedo, 1958, n.p.) [our emphasis].

The FAC was dissolved at the end of the federal-provincial agreement in 1960. A new agreement was signed (the Federal-Provincial Resource Development Agreement), but it was much broader in scope, including all resources important to native people's livelihood (C. Currie, Pers. Comm., 1978). The newly created Fish and Wildlife Branch now became the new mode of policy formulation for trapping.

2.4 Trapping and Forestry Policy Integration, 1960-1978

2.4.1 Introduction

By the close of the FAC era the issue of integration had changed significantly. The earlier interest in the effects of forest cutting on trapping, and the need to integrate management efforts, were diffused. This was because game species were mentioned as often, or more often, than furbearers. Few of the papers presented at the meetings discussed the effects of forest cutting on furbearer habitat. The Department of Lands and Forests' 1958 and 1959 Annual Reports are illustrative of how this issue is confused since they only discuss the impact of wildlife on timber. In the following section we will continue to trace this issue through the 1960's and 1970's. The discussion will not be presented at the same level of detail because the Ontario literature on fur management is not as abundant or detailed as it was during the Fur Advisory Committee years. Very few changes actually occurred during this period, and few new policies emerged. Instead, many of the previous problems remained unresolved and both policy and practice essentially remained static.

2.4.2 The Issue of Integration

By the early 1960's the concept of multiple use had become the guiding philosophy behind management policy.

> Our legislation has been revised on a multiple use basis so that the terms 'forestry purposes', 'forest management' and the like now officially include such things as fisheries and wildlife management (Clarke, 1962, 2).

What seems to be missing from this, and other literature at this time, is a clear statement of objectives for this multiple use philosophy (R. W. Behan (1967, 478) notes that this is a common omission). Thus, the rationale that would be applied in resolving problems of conflicting use is left to our imagination. The implications to resource management are significant, as under these circumstances one can only debate the rationale behind a decision after it has been made. Furthermore, the issue of integrating fur and forestry management was obscured by statements, such as the previous one, which suggested that co-operation and integration were part of daily management. But the following quote suggests that this was not yet the case, ". . . at no place in these responsibilities does the [timber] branch give any consideration to resources other than timber" (Charlton, 1964, 28).

In fact, it seems that foresters continued to view integration as the consideration of wildlife that was harmful to timber production. "It would appear as though wildlife is strictly a hitch hike or even a parasite as far as timber production is concerned" (Charlton, 1964, 17).

In the 1972 "Design Guidelines For Forest Management", a completely opposite and equally biased perception of wildlife is presented. In this document, wildlife ". . . is considered as the total spectrum of species that will <u>benefit</u> from cut modifications" (Hough, Stansbury and Assoc. Ltd., 1973, 91) [our emphasis]. The Guidelines go on to narrow the definition of wildlife to moose, the rationale being that moose habitat ". . . tends to be suitable for

most other species" (Hough, Stansbury and Assoc. Ltd., 1973, 91). These statements completely ignore furbearers (and other species) and their habitat requirements. The perception revealed in the Guidelines is a continuation of the wildlife/furbearer dichotomy that began in the late nineteen fifties in which wildlife was narrowly defined as species suitable for recreation and hunting.

It is quite obvious from the foregoing that perception has played an important role in the exclusion of furbearers from forest management plans. Yet forestry and other habitat altering activities were rapidly expanding during this period, leading one Lands and Forests worker to remark that "Only the relentless march of 'unplanned progress' with its attendant destruction of natural habitat could lose us our heritage of fur" (Gibbard, 1964, 4).

From the mid-sixties to the present, there is very little literature indicating progress in integrating forestry and trapping. Also, a literature search and discussions with various experts failed to reveal any evidence of government research on the impacts of forestry practices on furbearers. Broad statements such as "Much effort is directed to the maintenance and improvement of wildlife habitat as it is habitat which determines the potential of wildlife's numbers" (Ontario: Minister of Natural Resources, 1977, 15) suggest that research in this field is taking place. It is, but primarily for game species such as moose and deer.

One development that did promise integration of activities was the establishment of the Land Use Co-ordination Department in 1972. Its purpose is to co-ordinate the planning of land use through the

development of Strategic Land Use Plans (Ontario: Minister of Natural Resources Annual Report, 1976, 19). Examination of the 1974 "Background Information and Approach to Policy for North Western Ontario" (Ontario: Ministry of Natural Resources (MNR), 1974) report aimed at stimulating comment and discussion on proposed policies, reveals that trapping is not perceived as potentially conflicting with timber cutting. But if one compares future cutting areas and trapping activity (Fig. 2.1), the potential for conflict is quite obvious. This has been further demonstrated in the Reed Paper controversy (Suffling and Michalenko, 1980).

In 1977, the Phase II report of proposed policy for north-western Ontario was produced (Ontario: Ministry of Natural Resources, Proposed Policy North-Western Ontario, Strategic Land Use Plan Phase II, 1977). Again, there was no reference to potential conflict between fur and forestry. In fact, the report suggested that the harvest of fur in this part of Ontario be increased by 100 percent (Ontario MNR, Proposed Policy North-Western Ontario, SLUP Phase II, 1977, 33). It also indicated that the bulk of this increase would have to come from north of the 50th parallel. Yet there is no policy aimed at resolving or avoiding the potential conflicts that have been identified in this area. In addition, the lack of a comprehensive assessment of the potential impacts of forestry on trapping makes the above recommendations meaningless.

The one reference to the protection of wildlife habitat that was made in this document is narrow in scope, as the following quote illustrates:

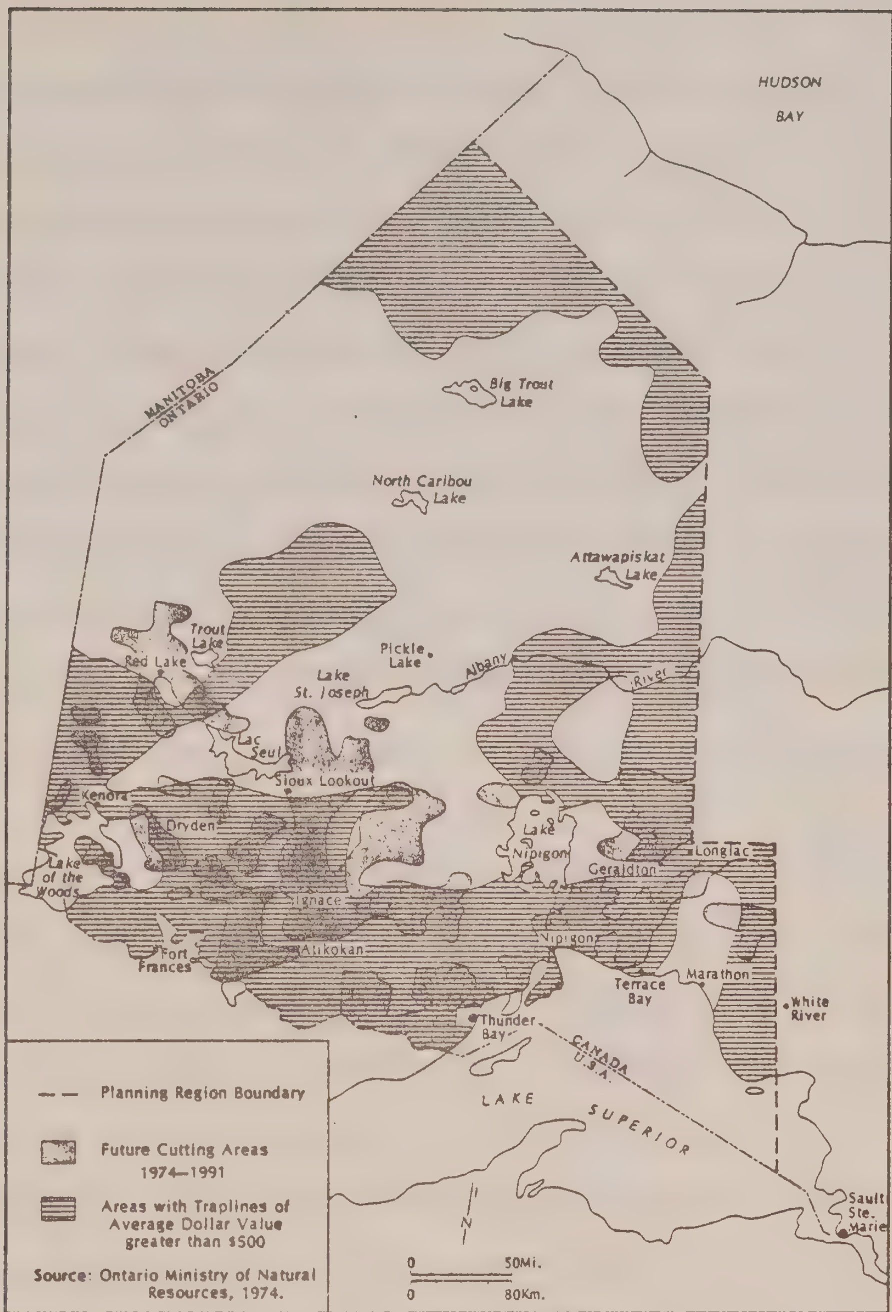

Fig. 2.1 Potential conflict between trapping and forest harvesting as identified from 1974 Strategic Land Use Plan information.

> [forest] harvesting designed to enhance good regeneration and wildlife habitat will generally be suitable for most recreation purposes . . . and hunting . . . (Ontario MNR, Proposed Policy North-Western Ontario, SLUP Phase II, 1977, 37).

This is another example of the wildlife dichotomy discussed earlier. Wildlife, as in the previous examples, is narrowly defined as species suitable for hunting and recreation, thus excluding most furbearers.

It is apparent that very little has been done to seriously pursue the issue of integration since the end of the FAC era. There has been no real integration of fur and timber management in the province, or any research that would enhance this possibility (C. Currie, Pers. Comm., 1978). Multiple use, a long-standing policy of the Ministry of Natural Resources, is still far from being implemented in an ecologically or economically logical fashion.

2.5 Analysis

Government fur management in Ontario made significant strides in the early years toward a truly holistic approach. The changes that occurred in the fifties are extremely significant when one considers the long history of laissez-faire attitudes that had prevailed in this resource industry. A significant development in the 1950's was the recognition of the need to integrate the management of potentially conflicting resource uses. The discussions of the integration of fur and forest management were far ahead of their time, and this, we believe, provided the key that could have opened the door to holistic management.

Yet, despite these advances, more recent issues and policy suggest that Ontario has not been able to put this new knowledge to use in forest management. The controversy that surrounded the Reed timber license proposal is prime evidence of this failure (RCNE, 1978). There is still no integration of furbearer and forest management (C. Currie, Pers. Comm., 1978). Why did this happen?

Perceptual bias is one of the most important factors affecting management policy. As White (1961, 29) noted, perception can "drastically limit the practical range of choice". Thus, different perceptions may lead to different sets of options for resource managers. Nowhere was this more apparent than in the narrow view of wildlife demonstrated by many foresters during both study periods. The forester's perception of wildlife showed professional and cultural bias that limited his attention to game and species which were detrimental to timber production. Since furbearers, other than beaver, do not fall into these categories, they have been ignored by most foresters. This is clearly illustrated by several of the papers presented in the late fifties at the FAC meetings (Giles, 1956; Dickenson, 1956; Bastedo, 1958); and, by the Minister of Lands and Forests Annual Report of 1959 (Ontario: Department of Lands and Forests, 1959, 37) which stated "The [wildlife and forestry research] program is designed to assess the damage by wildlife to the regeneration of timber." No statements were found suggesting the study of the alteration of wildlife habitat caused by the timber industry.

Another example of the way in which perceptions have acted to

impede progress in fur management is the general bias towards game that emerged in the Fish and Wildlife Branch, as illustrated in the following quote from the 1977 annual report:

> The Wildlife Branch objective is to manage, enhance and interpret wildlife populations and habitats to provide optimum wildlife based recreation opportunities for residents of Ontario . . . (Ontario Minister of Natural Resources Annual Report, 1977, 15).

Budgets have favoured research on game species with fur management receiving a smaller proportion of funding (Ontario MNR Annual Report, 1977, 30), thus reflecting the strong influence of Southern Ontario society on northern wildlife management priorities.

Institutional arrangements have reinforced these perceptual biases, despite the often stated advantage of having all the agencies responsible for natural resources in one department. The lack of overlap between forest and wildlife research is an excellent illustration of this. The forest resource inventories contain detailed information on forest stand characteristics and other data that could be useful in studying wildlife habitat. Yet, there have been no attempts by Government agencies to use these data or to assess their potential in fur management.

All of this has arisen because of the lack of a truly effective co-ordinating body. Yet the need for such an agency was pointed out as early as 1956: "The specialist within each group has his own responsibility and loyalty. He is not in the best position to recommend changes in use for the benefit of conflicting interests" (Morrison, 1956, n.p.).

The transfer of traditional economic rationale to wildlife

management is another factor which has interfered with the implementation of ideal management philosophies. This produced the dominant set of assumptions underlying and affecting policy formulation. Three important examples can be found. The first is that throughout the history of fur management, beaver has been the centre of attention. Most of the ecological research on furbearers has been devoted to this species because the beaver has provided the greatest economic return and is thus the 'bread and butter' of the trapper (St. Jules, 1972, n.p.; Ontario MNR, 1968, 83). The effort devoted to beaver was justified in the early part of the program because the trapper and industry would receive the greatest benefit in the shortest period of time. But beaver have continued to receive this attention through the 1960's and 1970's, despite great advances made in managing this species. The argument that it deserves preferred attention because of its economic value is no longer valid because of the success we have had in ensuring sustained yields. In addition, the market demand for species varies with fashion trends, as has been demonstrated by the recent increase in value of long haired pelts. Thus, a better long term strategy for both ecological and economic reasons would be to devote equal attention to several species.

A second example is the lack of research on habitat improvement and management. It was felt that this type of research was uneconomical for furbearers, yet a fair amount of this research was conducted for game species. This faulty reasoning was supported by the common conjecture that wildlife habitat in general was not threatened by forestry practices. The paradox is that the agencies

involved have acknowledged the importance of habitat management (Ontario MNR, Annual Report, 1977, 15). Yet, in spite of the massive alteration of habitat that has resulted from forestry operations this aspect of furbearer management has received little or no attention.

General policy statements and various reports suggest that a holistic ecological approach to management is being employed. But the failure to resolve certain issues and the actual management practice do not support this view.

The most salient feature of fur management that emerges in this study is what Caldwell (1975, 68) has succinctly described as "[the] . . . incongruence between belief and behaviour . . . a form of cultural schizophrenia . . . "

In conclusion, it seems that present policies are, for the most part, the result of incremental decisions and thus are ". . . as shortsightedly *ad hoc* as their original causes" (Holling and Clark, 1975, 248).

CHAPTER 3

THE TRAPPERS' FOREST ENVIRONMENT: DEVELOPMENT OF A TRAPPING SUCCESS/HABITAT MODEL

3.1 Introduction

One of the consequences of the fragmented approach to resource management in northern Ontario is the lack of a suitable data base for solving conflicting demands for furbearer habitat. Except for the Ontario Land Inventory (OLI)[1] capability classification for beaver, there is presently no obvious data base that could be used to address this problem. Even the OLI is deficient because it is not presented at a large enough scale for resolving many land use conflicts (Suffling, 1979, 67). There are, however, a number of essentially single purpose data bases gathered by various government agencies. Those data relevant to this study are the Forest Resource Inventory (FRI, collected by the MNR Forestry Division) and the Fur Harvest statistics (compiled by the MNR Wildlife Division). Previous furbearer-habitat studies are reviewed in Appendix 2.

3.2 The Study Area

The southern three 'working circles' of Reed Ltd.'s (now Great Lake's) proposed timber cutting area form the study area (see Fig. 3.1). This area was selected because it has not, for the most

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[1] See Appendix 1 for glossary of technical terms.

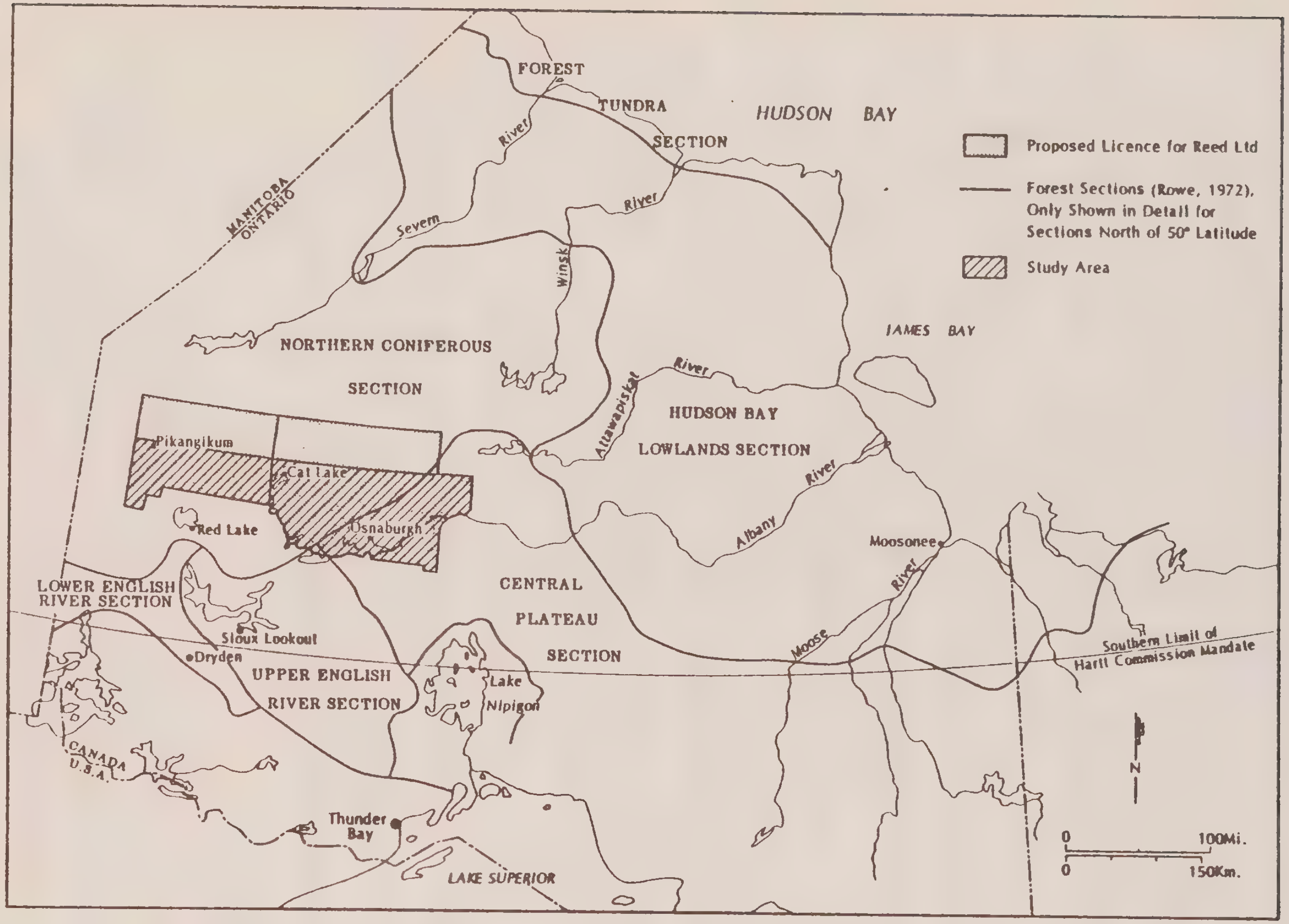

Fig. 3.1 The location of the study area and of the proposed Reed licence in relation to forest sections.

part, been logged and it contains many active traplines. In addition, abundant information on trappers and their behaviour can be found in the numerous anthropological studies conducted in the general area (Dunning, 1959; Rogers, 1962; Bishop, 1974). The southern working circles were selected because, when the work was started, FRI data were only available for this part of the proposed license area.

The area lies almost entirely within the Northern Coniferous Forest Section (Rowe, 1959). The remaining portion falls in the Central Plateau section (see Fig. 3.1). The topography in this part of the Canadian Shield is characterized by irregular relief and many lakes. There are a variety of fluvioglacial deposits throughout the area and several ancient beach ridges in the west.

Black spruce[1] is the most common tree, occurring in pure stands or with other species, mixing, for example, with jack pine on dry sites or with tamarack in wet areas. Jack pine is the second most common species. It also occurs in pure stands, especially on large upland areas that have been burned, but is more often associated with other species such as white birch, aspen, and white spruce. Mixed stands of white and black spruce, balsam poplar, balsam fir, white birch and aspen also occur.

There are approximately 41 government trapping areas within the study boundaries. Eighty-seven trappers were licensed to trap within these areas during the 1976-1977 season. Records are kept by MNR for the following species: beaver, mink, marten, fisher, lynx, fox, wolf, coyote, bear, wolverine, otter, muskrat, raccoon, squirrel, weasel, and bobcat.

[1] See appendix 1 for glossary of latin names.

3.3 Analysis

3.3.1 General Approach

The obvious approach to ascertaining the effects of logging on trappers would be to take a sample of trappers whose areas have been logged, and one whose areas are essentially undisturbed, and to follow these through time. If the trapline productivity of the two groups diverged one could conclude that logging had affected the trappers. Unfortunately this approach proved impossible because so many extraneous factors intervene; trapline boundaries have changed, trappers have moved, data are incomplete, and trappers' skills change over time. We have therefore adopted a number of alternative procedures as outlined below.

Having first assessed the strengths and weaknesses of the FRI data base and the fur trapping statistics (Appendix 3), a carefully selected sample of forest stands was classified into various types using two statistical procedures. These are known as cluster and discriminant analyses. Other habitat information not available from the FRI computer tapes was collected using FRI maps (Fig. 3.2).

The habitat data were used in various ways. First, they were incorporated with the fur trapping statistics in a procedure known as stepwise multiple regression. This showed which habitat features correlate with high or low catches of each furbearer species (Appendix 4). Then, because the results were not entirely satisfactory, the importance of each vegetation type to each animal species was assessed through trapper interviews. The furbearers were weighted according to their economic importance, and the two scores were combined to give a measure of the significance to the trapper of each habitat for individual animals and for all species together. Only the second method is considered in the main part of this report.

In chapter 4, the information gathered on habitats will be used

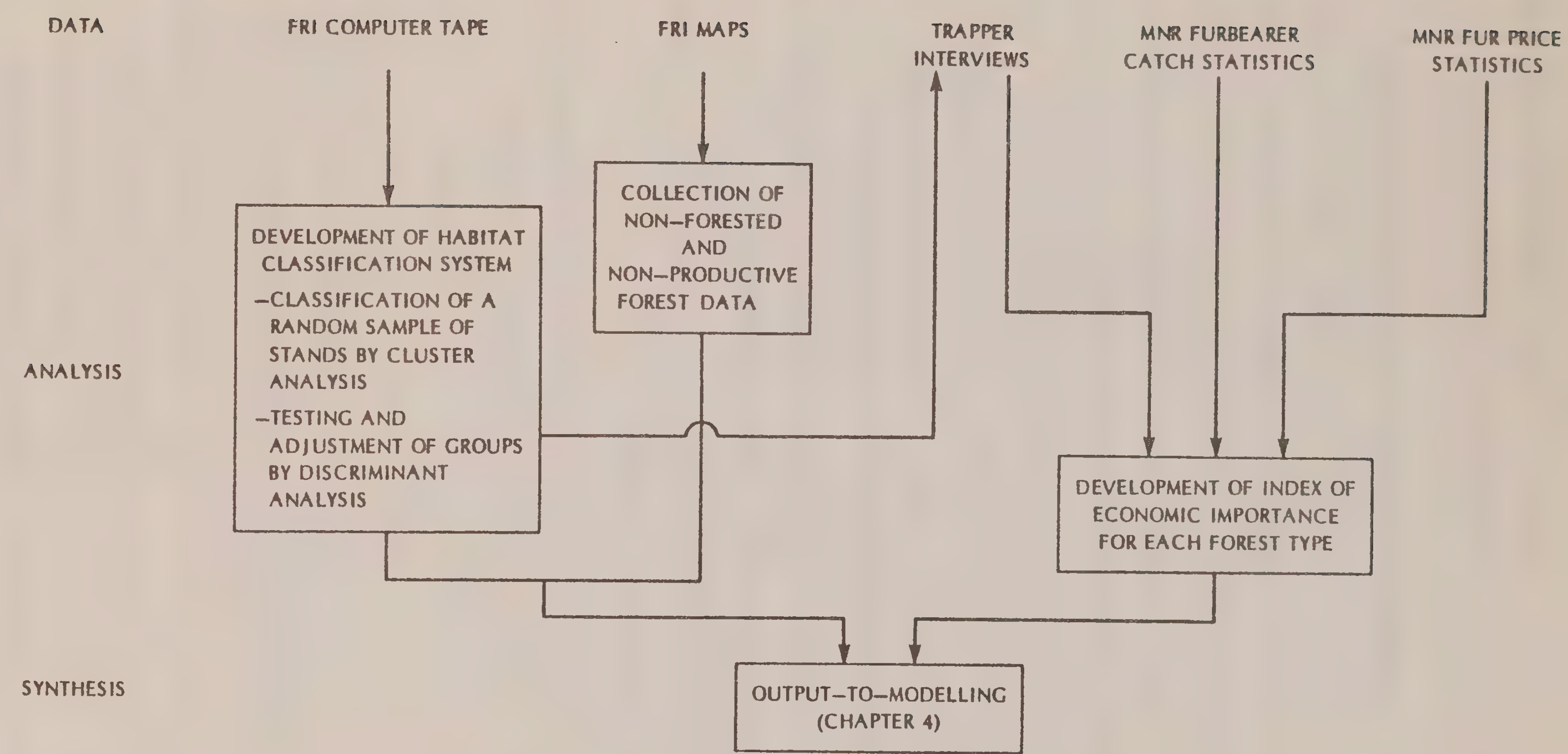

Fig. 3.2 General approach to analysis described in Chapter 3.

in a model of forest changes over time to show how the trappers' income may vary under different forest management regimes.

3.3.2 Development of a Habitat Classification System

Cluster analysis is a computer method of grouping a sample of individuals to form a number of discrete or overlapping homogeneous classes (Wishart, 1975, 1). The grouping is based on a measure of similarity between 'individuals' (in this case forest stands) derived from a number of descriptive characters such as species composition. This technique was selected because of its objectivity in creating groups and because it can be used to process a large amount of data quickly. Details of the cluster analysis method are given in Appendix 5.

The cluster analysis results and group threshold are depicted in Fig. 3.3, a dendrogram. The characteristics of the forest types chosen are summarized in Table 3.1, and their ecological and statistical validity is evaluated in Appendix 6. The selection of a sample of traplines is described in Appendix 7.

The collection of data on non-forested habitats was done by sampling the traplines used in the regression analysis (Appendix 4). The FRI maps for these areas were sampled using line transects as described in Appendix 7. This allowed tabulation of the areas of water, brush and alder, open bog, marsh, and barren and scattered areas (mostly burnt).

3.3.3 Development of an Index of Economic Importance for Each Habitat Type

In addition to the partially unsuccessful multiple regressions of trapping success and habitat (Appendix 4), we also made a series of estimates of the importance of each habitat to each furbearer using trappers' perceptions. Nineteen trappers were asked to flag

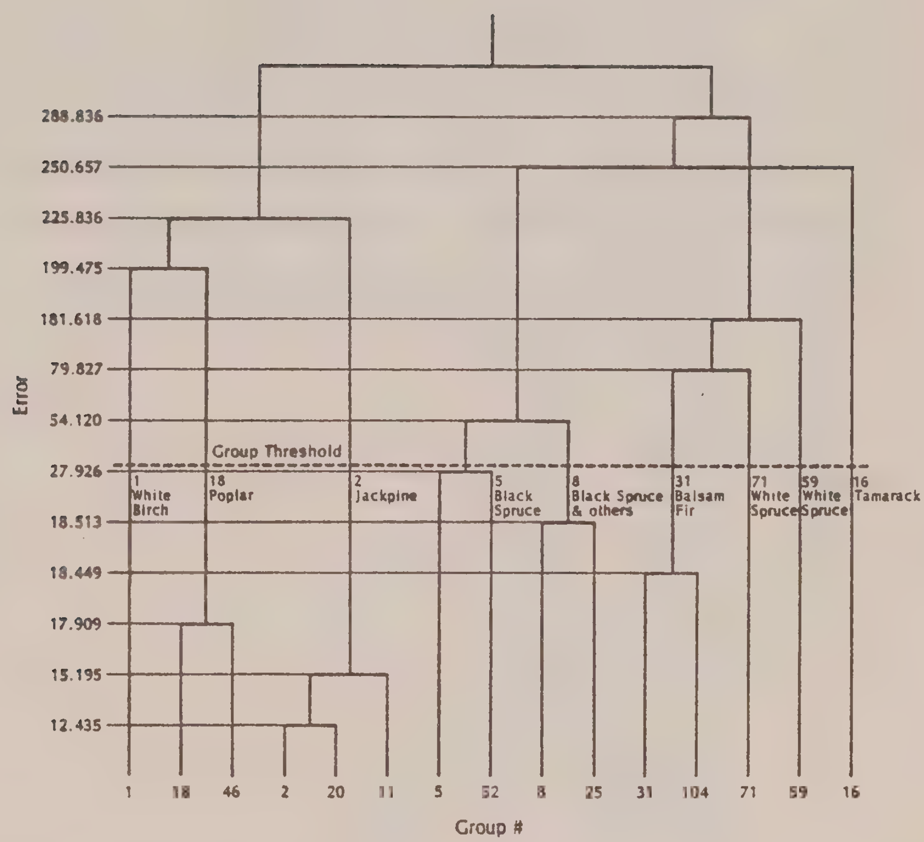

Fig. 3.3 Dendrogram of the forest classification developed through cluster analysis. There are 279 stands in the classification. Those groups which are most similar are joined low down on the diagram, and the nine types picked for use in the study are separated by the dotted group threshold line. They are described in Table 3.1.

Table 3.1: Tree Species Composition of Groups Identified in Cluster Analysis

CLUSTER ANALYSIS GROUPS	JACKPINE			BLACK SPRUCE			WHITE SPRUCE			BALSAM FIR			TAMARACK			POPLAR			WHITE BIRCH		
	avg*	max.*	min.*	avg.	max.	min.	avg.	max.	min.	avg.	max.	min.	avg.	max.	min.	avg.	max.	min.	avg.	max.	min.
5	0.6/0.9[1]	10.0	0.0	98.1/98.2	100.0	80.0							0.1	10.0	0.0	0.7/0.5	20.0	0.0	0.5/0.3	20.0	0.0
31	2.0/2.0	10.0	0.0	80.0/80.0	90.0	60.0	2.0/2.0	10.0	0.0	14.0/14.0	20.0	10.0							2.0/2.0	10.0	0.0
16				70.0/80.0	70.0	70.0						30.0	30.0/20.0	30.0	30.0						
8	20.3/18.7	50.0	0.0	62.6/62.6	80.0	40.0										8.7/9.7	40.0	0.0	8.4/9.0	40.0	0.0
2	76.5/76.5	100.0	40.0	15.0/15.6	40.0	0.0										3.9/4.1	20.0	0.0	4.6/3.9	40.0	0.0
59				25.0/25.0	50.0	0.0	55.0/55.0	60.0	50.0										20.0/20.0	40.0	0.0
71							40.0/40.0	40.0	40.0	30.0/30.0	30.0	30.0				30.0/30.0	30.0	30.0			
1	10.0/12.5	50.0	0.0	15.5/14.2	40.0	0.0										7.3/8.3	20.0	0.0	67.3/65.0	100.0	50.0
18	16.5/15.3	60.0	0.0	14.0/13.2	30.0	0.0										64.5/66.3	100.0	30.0	5.3/5.3	30.0	0.0

*average, maximum, and minimum per cent basal area.

[1]average per cent basal area after adjustments for misclassifications.

[2]blank spaces indicate that the species was not recorded.

which habitats they considered important for each species (see Appendix 8, question 9). In a previous survey of wild-rice harvesters we had found that respondents handled ranking with great difficulty. We therefore summed the number of respondents for each habitat to give a measure of its importance for each furbearer (Table 3.2). The habitats were defined to correspond closely with those developed above.

The results were weighted according to the economic importance of each species, determined from MNR pelt prices and the number of pelts of each species taken in selected unlogged parts of the study area (Table 3.3). The weighting was conducted as in Appendix 9, and the indices of economic importance are shown in Table 3.4.

3.4 Discussion

The analysis showed that, under present trapping management, the significant habitat types (in decreasing order of importance) are poplar, birch, marshes, alder, bogs, tamarack swamps, and black spruce swamps. This order is clearly heavily influenced by the importance of beaver. It is vital to bear in mind that poplar and birch are usually only significant if associated with nearby water capable of holding beaver.

The logged habitats (less than 10 years after logging) were thought by trappers to be very poor furbearer habitat compared with their unlogged counterparts (Table 3.2), but they were rated marginally more productive than comparable burnt areas. Other questions on the questionnaire (Appendix 8) indicated that trappers believe that burnt areas recover their furbearers more rapidly than

Table 3.2 Trapper+ Perceptions of the Importance of Habitat Types to Furbearer Species

FURBEARER SPECIES	HABITAT TYPE														
	Marshes	Bogs	Alder	Black Spruce Swamps(05)*	Tamarack Black Spruce & Alder Swamps(16)	Recently Burned Swamps	Recently Logged Swamps	Poplar & Other Species(18)	Birch & Other Species(01)	Jack Pine & Other Species (02)	Upland Black Spruce & Other Species(08)	Balsam Fir & Other Species (31)	White Spruce & Other Species (79)	Recently Burned Upland	Recently Logged Upland
Original values															
Beaver	0.11	0.05	0.16	0.05	0.07	0.02	0.01	0.24	0.23	0.01	0.01	0.02	0.02	0.01	x
Otter	0.30	0.27	0.07	0.09	0.09	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Lynx	0.03	0.01	0.09	0.08	0.15	0.03	0.04	0.06	0.06	0.16	0.10	0.09	0.05	0.03	0.04
Mink	0.24	0.24	0.14	0.19	0.10		0.02	0.02	0.02				0.02		0.02
Muskrat	0.08 *														
Fisher	0.04	0.05	0.07	0.13	0.13		0.01	0.08	0.08	0.12	0.13	0.06	0.11		0.01
Marten	0.04	0.03	0.05	0.12	0.09	0.02	0.04	0.05	0.05	0.14	0.12	0.13	0.08	0.02	0.04
Squirrel	0.04	0.02	0.06	0.11	0.08	0.03	0.04	0.08	0.08	0.11	0.13	0.09	0.06	0.03	0.04
Values adjusted for an unlogged landscape +															
Beaver	0.11	0.05	0.16	0.05	0.07	0.02		0.24	0.23	0.01	0.01	0.02	0.02	0.01	
Otter	0.31	0.28	0.07	0.09	0.09	0.02		0.02	0.02	0.02	0.02	0.02	0.02	0.02	
Lynx	0.02	0.01	0.10	0.09	0.16	0.03		0.07	0.07	0.17	0.11	0.10	0.05	0.03	
Mink	0.25	0.25	0.15	0.20	0.10			0.02	0.02				0.02		
Fisher	0.04	0.05	0.07	0.13	0.13			0.08	0.08	0.12	0.13	0.06	0.11		
Marten	0.04	0.03	0.05	0.13	0.10	0.02		0.05	0.05	0.15	0.13	0.14	0.09	0.02	
Squirrel	0.04	0.02	0.07	0.12	0.09	0.03		0.09	0.09	0.12	0.14	0.10	0.07	0.03	

\+ Based on a sample of 19 trappers.

x Blanks indicate zero values.

* Cluster analysis group (Fig.3.3).

$$\text{Value} = \frac{\#\text{ responses for habitat x}}{\text{Tot. }\#\text{ responses for all habitats}}$$

* Muskrat were omitted from the questionnaire but are found almost exclusively in marshes. A value of 1.00 is assumed.

$$+ \text{ Values} = \frac{\text{original value}}{1 - (\text{recently logged upland} + \text{recently logged swamp})}$$

Failure of some rows to add to 1.0 results from founding errors.

Table 3.3 Value of Pelts Per Trapper

	# Trappers Sampled	Beaver	Otter	Lynx	Mink	Muskrat	Fisher	Marten	Fox	Squirrel	Weasel	Wolf	Coyote
1972	75	233.68	54.58	19.43	25.24	7.76	0.89	0.31	0.17	0.15	0.05	.	.
1973	82	395.32	9.59	63.07	29.73	8.00	10.13	1.70	5.50	0.22	0.40	0.50	.
1974	47*	374.36	117.91	6.15	8.36	9.62	6.09	9.55	3.45	0.21	0.30	0.62	1.23
1975	45	286.56	109.22	2.82	17.11	16.71	.	6.16	0.69	0.31	0.27	.	.
TOTAL		1289.92	291.3	91.47	80.44	42.09	17.11	17.72	9.81	0.89	1.02	1.09	1.23
Fraction of Grand Total for all Years		0.70	0.16	0.05	0.04	0.02	0.01	0.01	0.01	T	T	T	T

*Change due to re-organization of MNR district boundaries.

Information Sources: 1. Statistical Supplement to the Annual Report of the Minister of Natural Resources. Years ending March 31, 1971 - March 31, 1977 (Average pelt value).

2. Ministry of Natural Resources furbearer pelt statistics. Red Lake District Office (Number of pelts).

T–Less than 0.005

Table 3.4 Economic Importance Values * of Habitat for Furbearer Catch Based on Trapper Perceptions and Government Pelt Statistics

FURBEARER SPECIES	Marshes	Bogs	Alder	Black spruce swamps (05)*	Tamarack, black spruce & alder swamps (16)	Recently burned swamps	Poplar and other species (18)	Birch and other species (01)	Jack pine and other species (02)	Upland black spruce and other species (08)	Balsam fir and other species (31)	White spruce and other species (71)	Recently burned upland	TOTAL
Beaver	0.077	0.035	0.112	0.035	0.049	0.014	0.168	0.161	0.007	0.007	0.014	0.014	0.007 *	0.700
Otter	0.048	0.043	0.011	0.014	0.014	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.154
Lynx	0.000 *	0.001	0.005	0.004	0.008	0.002	0.003	0.003	0.008	0.005	0.005	0.003	0.002	0.049
Mink	0.010	0.010	0.006	0.008	0.004		0.001	0.001				0.001		0.041
Muskrat	0.020													0.020
Fisher	0.000 *	0.001	0.001	0.001	0.001		0.000 *	0.001	0.001	0.001	0.001	0.001	0.001	0.010
Marten	0.000 *	0.000 *	0.001	0.001	0.001	0.000 *	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.010
Sub-total	0.155	0.090	0.136	0.063	0.077	0.019	0.176	0.170	0.020	0.017	0.024	0.023	0.014	0.984
Other Species +														0.010
Grand Total														0.994

(The column heads Marshes to Recently burned upland are grouped under the spanning heading HABITAT TYPE.)

* Cluster analysis group.

* Less than 0.0005

* Failure to add to totals in Table is due to rounding errors.

\+ Squirrel, weasel, fox, wolf, coyote.

* The total value of the catch of all species is taken as 1.00.

logged areas. The implication is clear, however, that both logging and forest fires decrease furbearer production significantly in the early years following disturbance.

CHAPTER 4

CHANGES IN THE TRAPPERS' FOREST ENVIRONMENT OVER TIME

4.1 Introduction

The objective of this chapter is to show how present characteristics of the northwest Ontario landscape have been moulded by events in the past, and how changes in the processes involved, such as fire and logging, will alter landscapes in the future. The implications of these changes to trappers will then be demonstrated.

4.2 A Demographic Approach to Landscapes

4.2.1 Background

To the human eye the present landscape is static, but we see only a cross-section in time of a constantly changing pattern of ecosystems. We cannot contemplate intelligent management of any landscape without considering how it will change, both with and without any proposed alterations in management. Knowledge of three elements is essential to making predictions about ecosystems:

1) What is the present state of the ecosystem?
2) To what state is it headed, based on past experience?
   (How has the system changed in the past?)

3) How will the future system differ if some new management is implemented?

Organisms live, not in single isolated ecosystems, but in landscapes where a mosaic of ecosystems forms a more or less recurring spatial pattern. Some more mobile animals, such as man, survive better in such a mosaic of systems because their habitat requirements are not wholly satisfied by one ecosystem type. Others, while requiring but a single habitat, are unable to survive in one place because, while their requirements are static, the habitat itself is modified through natural successional change. New habitats must be made available in the landscape mosaic as others become unsuitable. This is seen most clearly in the case of pioneer species: those such as the ruffed grouse, which colonize recently disturbed areas. The characteristics of a landscape as habitat for man or other organisms will thus depend in large part on the proportions of ecosystems of different ages.

4.2.2 Theoretical Age Distributions

Imagine a hypothetical landscape in which disturbance factors such as fire are constant in occurrence over relatively large time periods, and across extensive landscape regions (such as those defined by Rowe, 1972). A simulation can be developed which shows the age distribution of ecosystems in the landscape, developed under various assumptions (Figure 4.1). The area of ecosystems in younger age groups is always predominant in this equilibrium, but the shape of the distribution varies depending on whether there is a greater (A) equal (B) or lesser (C) chance of disturbance with respect to

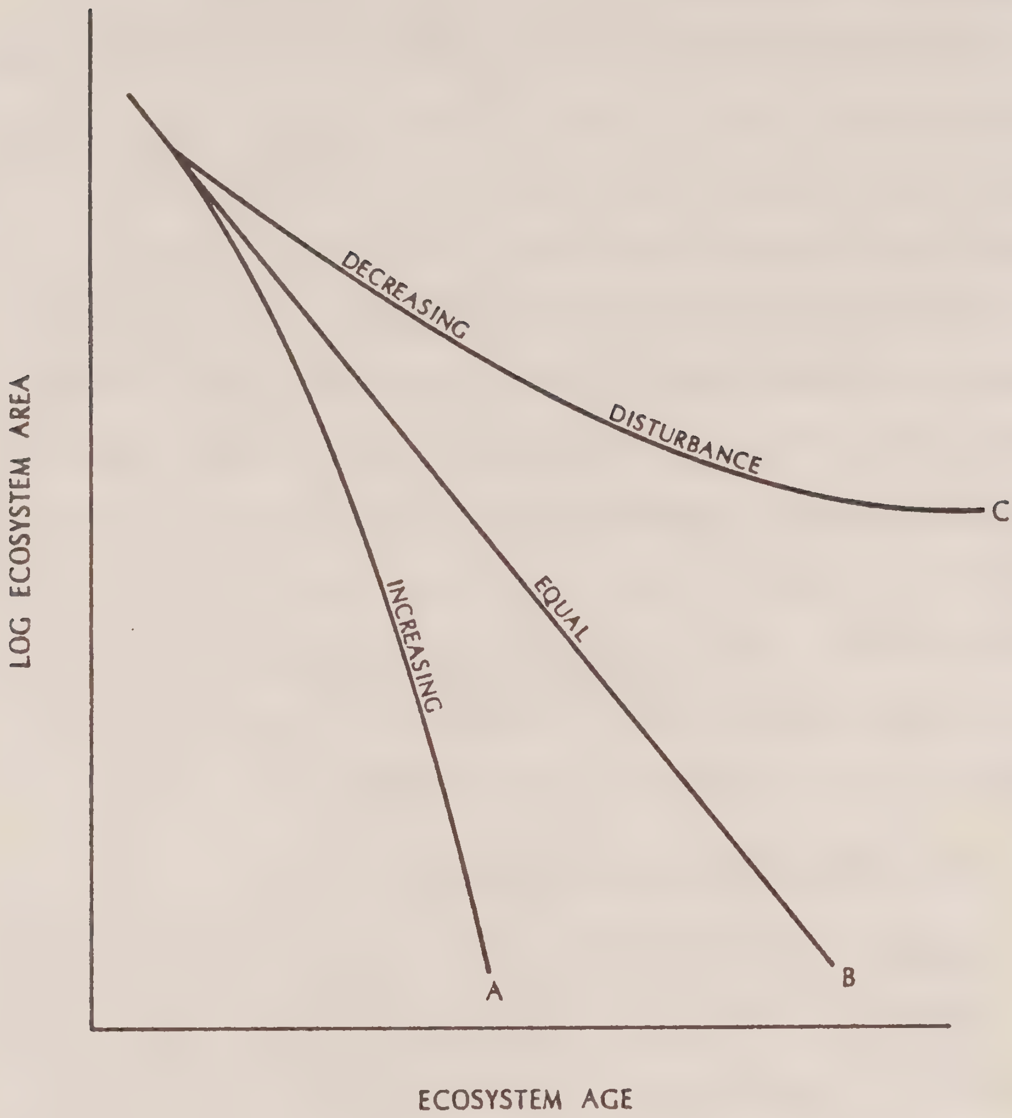

Fig. 4.1 Theoretical age distributions of ecosystems in a landscape. Curve A represents a landscape where there is more chance of disturbance such as fire in older ecosystems; curve B describes a landscape in which there is an equal chance of disturbance with respect to age. In curve C, young ecosystems are most prone to disturbance.

advancing ecosystem age. These curves bear a striking resemblance to survivorship graphs in traditional population ecology. They differ from the latter, however, in that the destruction ('death') of a certain ecosystem through some catastrophic event results in the immediate creation ('birth') of a corresponding pioneer ecosystem. The population of ecosystems is fixed in size as long as the area rather than number of stands is the standard of measurement.

4.2.3 Observed Age Distributions

One frequently finds distributions of type B in Northern Ontario for upland, fire-prone sites (Figure 4.2). This indicates that, beyond about 60 years the chances of a forest being burned are approximately equal. The anomaly in the younger age classes will be discussed below.

In contrast, the lowland forests (those growing on shallow or deep peat) show a very different age distribution (Figure 4.3). Here one finds that, as with the upland forests, there is an anomalously low area of young stands, and that there is very little indication of destruction of older stands until they reach more than 160 years of age. There are two explanations:

1) There was very little fire in lowland areas more than 160 years ago.
2) Lowland forest stands of more than 160 years are prone to burn, whereas younger ones are not.

With the information which we have at present we cannot endorse either of these positions wholeheartedly.

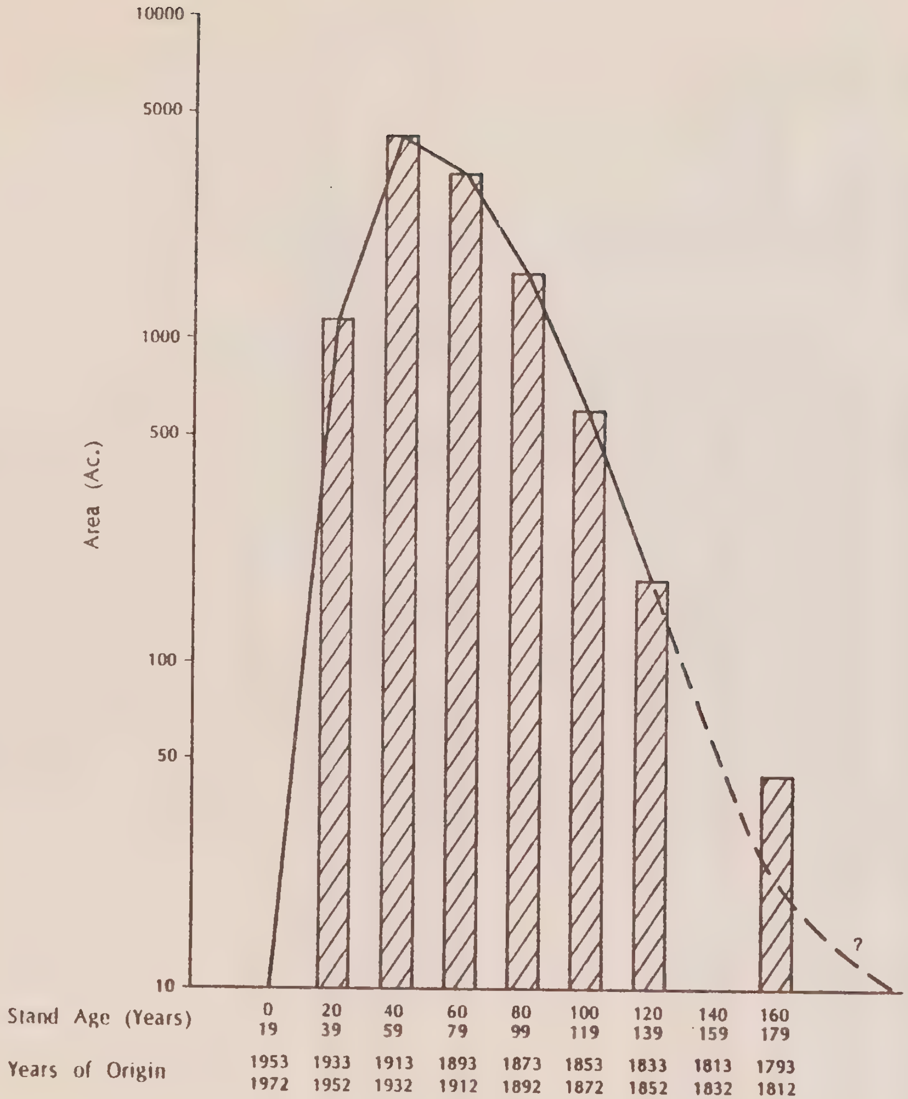

Fig. 4.2 The age distribution of the upland forest stands used in the cluster analysis.

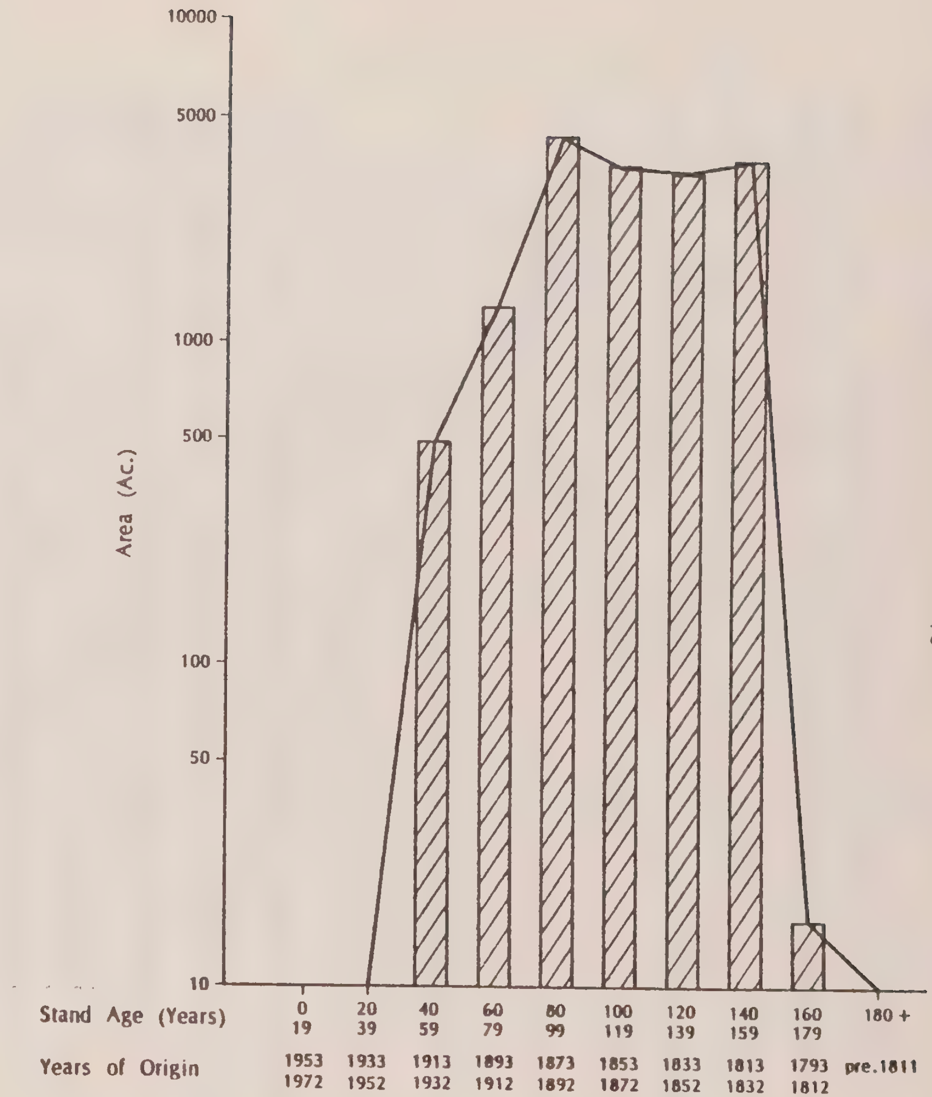

Fig. 4.3 The age distribution of the lowland forest stands used in the cluster analysis.

These forest age distributions for Northern Ontario do not represent an equilibrium situation assumed in the theoretical base discussed earlier. There has been a universal decline in the rate of forest fires in recent decades throughout Northern Ontario (Table 4.1). This is the reason for the small area of young stands pointed out above. The decline has not yet been balanced by the increase in logging activities in the north.

Three hypotheses have been examined so far to account for the observed decline in disturbance rates around 1905 and around 1925. They are:

1) That there was a change in climate, probably a cooler wetter phase. The available data suggest that the weather in fact became warmer and drier in the first quarter of this century (Figure 4.4) which would be expected to promote forest fires. There has been a cooling trend since about 1940.

2) That effective fire fighting techniques were first employed around 1915-1934. In fact, there seems to have been such a trend around 1945 with the advent of water bombers, but it does not invariably coincide with the data trend.

3) That the change in climate would suppress insect disease outbreaks. For spruce budworm, at least, this is not the case. Epidemics are promoted by warm dry weather (Blais, 1954).

Table 4.1: Years When the Rate of Ecosystem Disturbance Changed Dramatically in Various Areas in Northern and Eastern Ontario

Management Unit or Licence Area	Last time period before decline in rate of ecosystem disturbance
Pitopiko M.U.	1854-1873 (1894-1913*)
Red Lake W.C.1.	1875-1894
Johns Manville	1892-1911
Bancroft/Dacre	1894-1913 (1914-1934*)
Burwash M.U.	1895-1914
Pineland Timber Co.	1895-1914
Elk Lake M.U.	1911-1930
Sturgeon Falls W.C.1.	1911-1930
Eddy M.U. W.C.2	1914-1933
Berens River M.U.	1915-1934
Austin M.U.	1915-1934
Gogama M.U.	1915-1930
Great Lakes Paper W.C.1.	1916-1935
Spruce Falls	No peak in histogram

*Subsidiary peak

Source: MNR Forest Resources Inventory Summary Statistics by Management Unit.

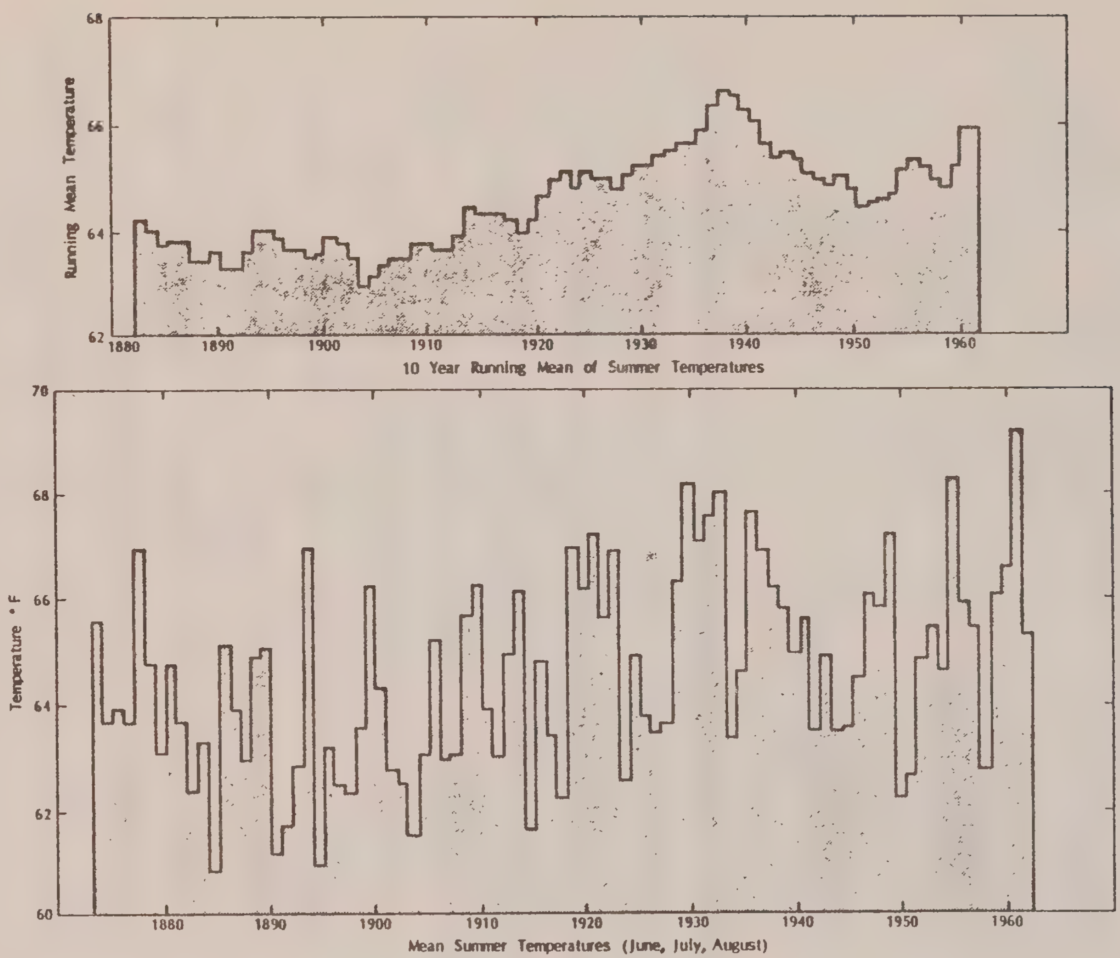

Fig. 4.4 Long-term temperature changes for Winnipeg. (After J.J. LaBelle, R.J. Brown and M.D. Hasinoff. Can. Dept. Transport Meteorological Branch. Circ. 4437. 1966. Toronto.)

Fire control is the most likely cause of the decline in forest disturbance, and it must be taken into account in a variety of land management contexts; in timber harvesting, in park management, in fur harvesting, and in cost benefit analysis of fire control. A model of these past landscape changes and possible future scenarios is developed in Appendix 10.

4.3 Scenarios for the Future

4.3.1 General Observations

The results of the modelling exercise are presented in Figures 4.5 and 4.6. Because of our inability to break the data down into the smallest forest type divisions (see p. A10.6) we have had to interpolate the proportions of different forest types by extrapolating from the present. Thus, for instance, if 20 per cent of the forest of age 20-39 years belongs in forest type 08 we have assumed that this is so in all future cases. There are distinct differences, however, between the regeneration after logging and after fire, so that we have less confidence in the logging scenario than in the natural and fire control situations. We also have more confidence in the lowland-logged than in the upland-logged scenarios.

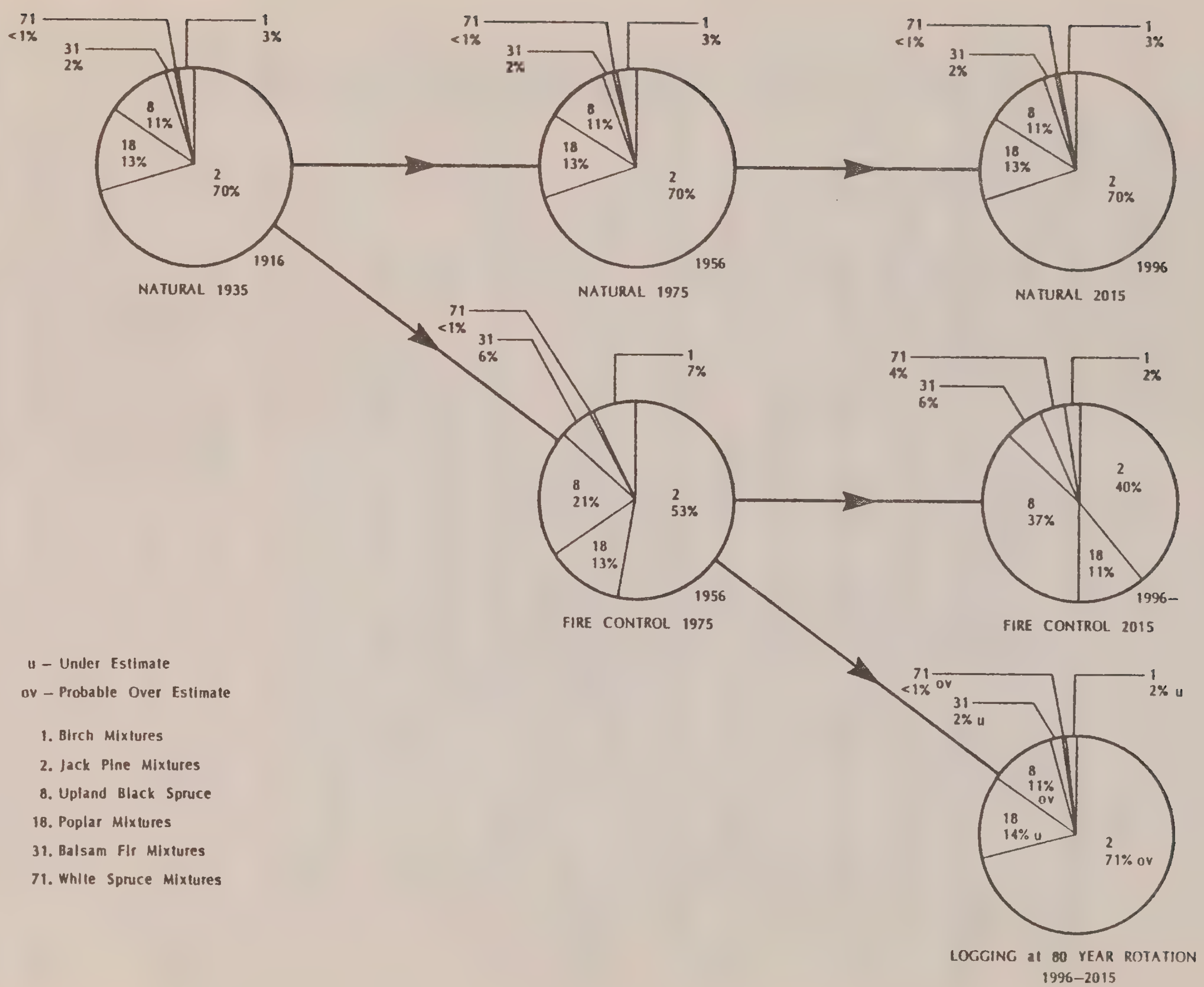

Fig. 4.5 Estimated and predicted predominance of various ecosystem types in the upland landscape during three scenarios.

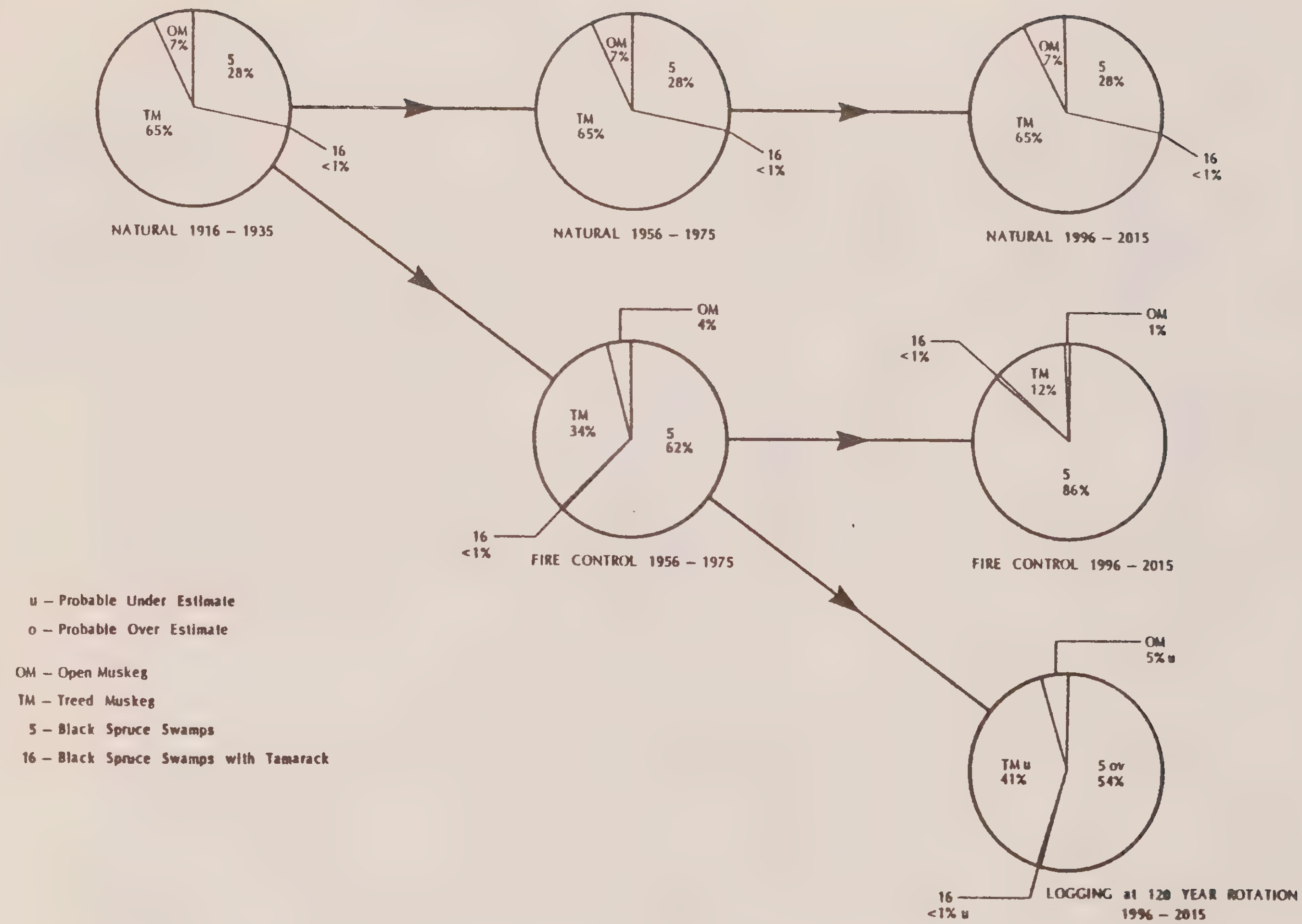

Fig. 4.6 Estimated and predicted predominance of various ecosystem types in the lowland landscape under three scenarios.

Because of these concerns, some of the proportions in Figures 4.5 and 4.6 are marked to show probable underestimates and overestimates. In all cases logging is assumed to proceed at the maximum rate compatible with the rotations described on page A10.12.

4.3.2 Upland Forest

Had there been no fire control in the study area, one might now expect to see a landscape with much more jack pine and about half as much black spruce communities. There would be fewer mature fir and white spruce stands and also a lesser amount of birch which results primarily from the break-up of senescent stands. The natural situation would not change significantly in the future.

By the year 2017 it is expected that, with fire control only, the present forest will have changed significantly. There will be large reductions in the areas of pioneer forests such as those dominated by aspen and by jack pine. There will be a corresponding increase in black spruce and white spruce stands. Because of the extreme ages of many stands, the birch forest will be reduced in area and will have largely turned into white spruce mixtures.

With logging, the age distribution of the upland forest in AD 2017 would change relative to that with fire control only. Because of the method of apportioning forest types, the logged model result shows a distribution approximately that of the natural forest. However, regeneration after logging will differ from that after fire (Table 4.2) so that the acreages of jack pine and black spruce forests would in fact probably be reduced while those of the birch and poplar groups would increase relative to the natural situation.

Table 4.2: Regeneration After Logging and Fire

Original Forest Type		Probable New Forest Type in Decreasing Order of Importance				
01 White Birch	L	01	18	31	02	08
	F	18	02	01	08	
02 Jack Pine	L	02	18	31	08	
	F	02	08	18	01	
05 Swamp Black Spruce	L	brush & alder	open muskeg	18	05	
	F	open muskeg	brush & alder	05	18	
08 Upland	L	18	02	31	08	
Black Spruce	F	08	02	18		
16 Black Spruce with	L	16	brush & alder	05		
Tamarack	F	05	brush & alder	16		
18 Poplar	L	18	31	02		
	F	18	02	08		
31 Balsam fir	L	18	31	02		
mixtures	F	02	08	01		
71 White Spruce	L	18	31			
mixtures	F	18	08			

L = After logging
F = After fire

4.3.3 Lowland Forest

Had there been no fire control in the lowland forest to the present time, one would see a landscape with much less mature black spruce forest, and much more treed muskeg. The area of open muskeg would also be nearly twice as large (Figure 4.6).

Further fire control alone to the year 2017 will result in a lowland landscape dominated by mature or maturing black spruce stands with less than half as much treed or open muskeg as at present. Institution of logging from now until the present will result in moderate changes from the present, involving an increase in treed and open muskeg relative to swamp black spruce stands. In no case above will the importance of tamarack change very much, though there might be moderate increases following logging.

4.3.4 General Conclusions on the Landscape Model

Fire rates have already been markedly reduced, and this is most evident in the lowland, partly non-commercial, forests and other wetlands. With further fire control the landscape will change even more dramatically than it has to date. Heavy logging will restore the age distribution of the commercial part of the forest to something approaching the original state, but the character of the landscape will be different from that to be expected without logging or fire control. There will be a greater proportion of mixed stands of conifers and deciduous trees in the uplands. These findings are broadly parallel to those of the Quetico Park Fire Study conducted by the Ministry of Natural Resources (Woods and Day, 1977).

4.3.5 Predicted Influence of Habitat Changes on Furbearer Harvest Values

Application of the economic importance scores developed for each habitat (p. 28) shows (Table 4.3) that the present fur harvest is probably slightly lower than would be the case in a landscape with no fire control. If fire control continues in the absence of logging, the fur harvest value will probably drop further, but the total decline will only be in the region of 10 per cent. Application of logging at the maximum rate compatible with sustained yield will result in a harvest value not differing very much from that with fire control above (i.e., about 10 per cent lower than the 'natural' situation.)

The above conclusions apply to the whole landscape. Inspection of the logging pattern on individual traplines (Figure 4.7) shows that the local effects of timber harvesting may be drastic when a large proportion of mature forest is replaced by recently logged areas having little merit for furbearer production. It must be remembered, however, that large wildfires will have a similar effect on individual traplines.

Table 4.3: Estimated and Predicted Changes in Fur Harvest Value[±] Based on Habitat Changes

	No Fire Control or Logging			Fire Control only			Fire Control and Logging		
	Upland	Lowland	Total	Upland	Lowland	Total	Upland	Lowland	Total
1917-1936	0.42	0.68	1.10	-	-	-	-	-	-
1957-1976	0.42	0.68	1.10	0.44	0.54	0.98*	-	-	-
1995-2015	0.42	0.68	1.10	0.37	0.50	0.87	0.34	0.55	0.89

± Based on Economic Importance Values (see Table 3.4).

* Present value should be 1.0 Slight inaccuracy results from rounding errors.

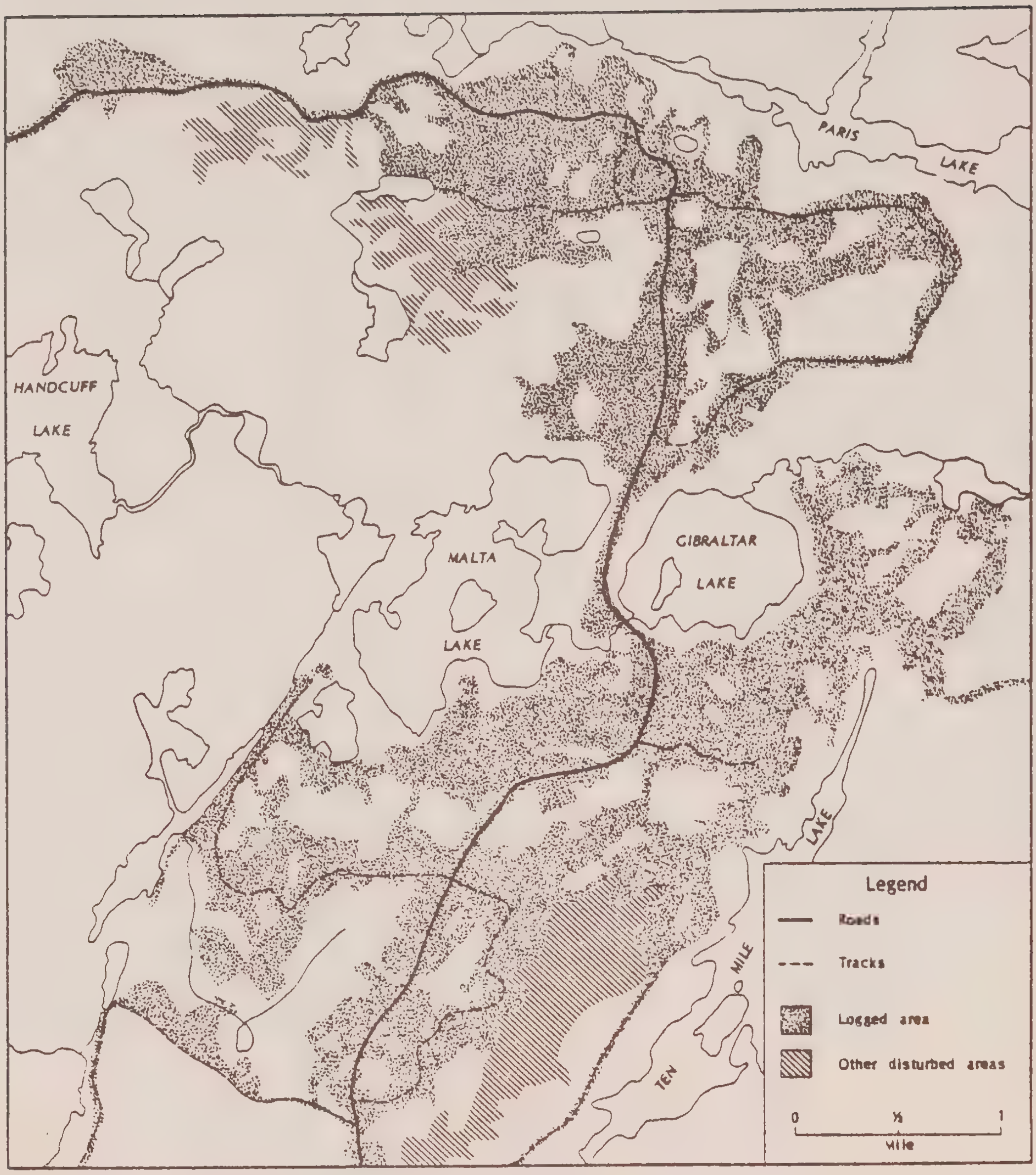

Fig. 4.7 Logging in an area east of Sioux Lookout, summer 1975. Logging was still in progress when the air photographs from which the map was made were taken.

CHAPTER 5

SOCIO-ECONOMIC EFFECTS OF LOGGING ON TRAPPERS

5.1 Introduction

The interview survey of trappers (appendix 8) was conducted between October 1979 and January 1980, using two interviewers from northwestern Ontario. Some additional interviews were conducted by one of the authors. Twenty-one interviews were made, though in one case a whole family of trappers was involved so that 23 trappers were surveyed. The small size of the sample precludes a rigorous statistical analysis, but in many instances the responses of the trappers was so consistent that none is required in any case. The results of the survey are summarized below. The headings below reflect a number of basic questions.

5.2 A Profile of the Trappers

A statistical description of the trappers (Table 5.1) shows that about two-thirds are natives, all but one are men, and there is a wide spread of age and trapping experience. The lack of younger trappers occurs because the interviewers tried to avoid engaging novice trappers in interviews.

Table 5.1: Profile of the Trappers Interviewed

Sample size: 21 interviews involving 23 trappers.

Male: 22 Female: 1

Native: 14 Non-native: 6 Not known: 3

Age distribution:

	Not known	under 20	20-29	30-39	40-49	50-59	60-69	70 years or more
Number of trappers	1	0	4	4	6	3	4	1

Area where trapline is held:

Savant Lake	6
Allanwater Bridge	1
Lac Seul	7
Sioux Lookout	8
Hudson	1

Years of trapping experience:

	Not known	Less than 10	10-19	20-29	30-39	40+
Number of trappers	4	5	4	6	2	2

5.3 How Do Trappers Feel About Logging?

The questionnaire was administered in such a way that the interviewees were not aware of the basic purpose. The topic of logging was not introduced by the interviewer until near the end of the discussion. Nevertheless, this matter was raised frequently by the trappers. Table 5.2 shows that half the trappers had negative feelings towards logging, but a further breakdown is more informative. Only one-quarter of those whose areas had not been logged felt negatively, but every trapper whose area had been logged even slightly was opposed to logging on traplines. We conclude that feelings against logging are engendered by logging itself and are not merely a prejudice.

One comment from a more articulate trapper is reproduced in full in appendix 13. Specific comments range from the general ('We've got to do something about it', and 'trapping is finished by logging') to more specific statements on the destruction of habitat and decline of various furbearers. Two trappers were concerned about the use of herbicides. Comments on logging as employment are covered below.

5.4 How Do Trappers Feel About Logging Roads?

Trappers' attitudes to logging roads were much more ambivalent than to logging itself. Only eight trappers made any comments, and positive and negative comments were evenly split (Table 5.3). Trappers felt that access from roads is to their personal advantage in that it allows them to use the trapline more effectively, and

Table 5.2: Trapper Attitudes Towards Logging Effects on the Trapline

Attitude towards logging on traplines	Proportion of Interviewees' Trapline Which Has Been Logged				
	Less than 10%+	10-25%	26-50%	More than 50%	Total
Positive	0 *	0	0	0	0
Neutral, ambivalent, or no comment	10	0	0	0	10
Negative	5	2	3	3	13
Total # of trappers	15	2	3	3	23

* Number of trappers.

\+ In 3 cases logging had occurred 30-60 years ago.

In 2 of these cases logging was just starting at the time of the interview.

Table 5.3: Trapper Attitudes Towards Logging Roads

Proportion of Interviewees' Trapline Which Has Been Logged

Attitude towards logging roads on traplines	Less than 10%+	10-25%	26-50%	More than 50%	Total
Positive	1*	1	0	1	3
Neutral, ambivalent or no comment	12	0	3	2	17
Negative	2	1	0	0	3
Total # of trappers	15	2	3	3	23

* Number of trappers.

\+ In 3 cases logging had occurred 30-60 years ago.
In 2 cases logging was just starting at the time of the interview.

to travel off the trapline more easily. At the same time, there was concern that some sport hunters who arrived bv road poach furbearers, and all compete with the trappers for game. There were several reports of traps being tampered with following road building.

The question of the effects of roads on schooling will be covered below.

5.5 How Do Trappers Feel About Forest Fires?

Nine trappers commented that forest fires damage traplines, either by destroying cabins or by habitat degradation. The loss of marten habitat was cited specifically in several cases. Three trappers were of the opinion that fire is beneficial, at least in the long term. Three of the respondents had worked at fire fighting.

5.6 What Effect Does Logging Have on Trappers'Activities?

When asked about changes in trapping success, three respondents complained about reduced marten numbers following logging, while two others cited reductions in lynx and fisher, and one complained of a reduced beaver catch. When they were asked if they knew of any trappers who had had to abandon trapping because of logging, most respondents said that they did not, but three cited the case of Mr. Bob Champagne of Savant Lake who has apparently moved to Alberta because a logging camp was built very close to his cabin. One trapper in the survey had moved his trapline because of logging, and another respondent said that he personally knew 'several' people in Ear Falls who had given up trapping because of logging activities. One trapper replied that he 'had to take a job with a logging company' because of damage to his trapline.

5.7 What Effects Do Logging Roads Have On Trappers?

It was obvious from the survey that roads have complex effects on the trappers' lifestyle. They may be summarized as follows:

1) Roads provide access which trappers value (5 responses).

2) Roads increase competition for game from sport hunters, and traps are tampered with or robbed. There is some illegal shooting of beaver and other species by hunters (4 responses).

3) Roads make it possible for a trapper to live in town or on a reserve and send his children to school, yet he can still hold a trapline. Several people with children had chosen this option, but in one case the trapper had ended by giving up trapping for the winter. Two families stated that they had opted to live in a settlement for the winter because they felt that if they did not send their children to day school they would be taken away and put into a boarding school. The road thus offers both an opportunity and a constraint to trapping where it conflicts with a child's schooling.

4) Roads cause a significant number of road kills of furbearers (2 responses).

5.8 What Effect Does Employment Have On Trappers?

Many of the respondents had been involved in other forms of occupation, which is only to be expected with a seasonal trade such as trapping. Other activities included logging, caretaking of a camp,

running a fishing camp, wild ricing, commercial fishing, fire-fighting, and bait fishing. In one question, trappers were asked to rate their choice of various occupations (Table 5.4). All were evidently satisfied with trapping as a lifestyle and preferred it to all others. Industrial work in mines and welfare were least preferred and the next most disliked occupations were live-in logging operations and other wage labour. The most preferred alternative to trapping was logging on a commuting basis.

The next pertinent question is whether logging actually provides an alternative for those whose traplines are damaged by forest harvesting. Table 5.5 shows, surprisingly, that only one quarter of the trappers surveyed had worked at logging recently, and that the percentage in the case of those whose traplines had been logged was essentially no higher than in the unlogged group. It is concluded that logging does not necessarily absorb wholly or partially displaced trappers. We have not had time to ascertain whether this is because trappers prefer not to work at logging (in spite of the sentiments expressed above) or whether they cannot adjust to a wage labour situation. We suspect that the latter is the case. One complicating factor in interpreting the information is that some of the trappers whose areas have been logged are 'part-timers' who work in a variety of wage labour situations anyway and whose employment pattern will not change if trapping becomes more difficult.

5.9 To What Extent Does Trapping Provide Benefits Not Normally Recognized by the Wider Community?

The benefits of trapping which are not normally appreciated by 'outsiders' may include the following:

Table 5.4: Trappers' Employment Preferences

Occupation	Number of Responses		
	Liked	Neutral	Disliked
Trapping	17	2	0
Logging (live at home)	6	7	6
Other wage labour	3	13	3
Logging (live in camp)	2	7	10
Mining	1	2	16
Welfare	0	7	12
Pulp Mill	0	3	16

(Four trappers did not respond to this question in the questionnaire).

Table 5.5: Logging as an Alternative or Supplementary Occupation For Trappers

Proportion of Trappers' Trapline Which Has Been Logged

	Less than 10%	10-25%	26-50%	More than 50%	Total
Number of trappers recently employed in logging	4	0	1	1	6
Total number of trappers	15	2	3	3	23
Proportion of trappers	27%		25%		26%

1) Housing.

2) Food.

3) Conversion of furs to handicrafts which adds to their value, and results in their not being included in trapping returns.

4) Fuel.

Five of the twenty-three trappers live in the bush and thus have free housing which is a consequence of their occupation. The remainder have residences in towns or hamlets, or on Indian Reserves.

All of the trappers take some meat from their traplines in one form or another. The furbearer animals used are beaver, supplemented by lynx and muskrat. Some of the hunters mentioned snaring hares, and most if not all hunt moose. These are supplemented by fish as detailed below (see Table 5.6).

Nearly one-third of the trappers gain more than half their family's meat supply while trapping, and for nearly 70 per cent of those interviewd the meat supply from trapping is significant (Table 5.6). If logging has an effect on the viability of traplines it will presumably hit the most active trappers hardest and these are precisely those who rely most heavily on trapping/hunting forays for meat.

The response of trappers to a supposed cutback in trapping is also of interest. Of those who do gain meat from the trapline in quantity, about one-quarter said that they would decrease or at least not increase their hunting effort if trapping was not available. Of the remainder, it is probable that not all could or would increase hunting sufficiently to compensate for the trapping loss.

Table 5.6: Proportion of Meat+ Trapped and/or Shot While Trapping

If Trapper Stopped Would	None *	25%	25-50%	More than 50%	'Don't Know'	Total
a) Make special trips	1	4	1	5	1	12
b) Would cut down on hunting/fishing	0	1	0	1	0	2
c) It would make no difference	2	1	0	1	0	4
d) No response	0	2 x	0	0	2	5
Total	3	8	1	7	3	23

\+ Eaten by the trapper and his family (where applicable).

* All trappers use some meat, but in these cases the quantity was insignificant.

x One other respondent said that if he couldn't trap, he "wouldn't get beaver unless they were given to him."

The question of fishing was less easy to answer. Only six trappers admitted to fishing at all while trapping, but there are indications that most trappers net fish illegally for trap bait, and presumably they consume some of these fish also. This supposition is supported by the response on fish eating habits. Only six trappers claim to fish while trapping but eight obtain a significant proportion of fish while trapping! In winter, most fish will not take a baited hook, so almost all fish eaten must be netted during bait fishing. As a consequence, any fishing done while trapping might not be continued if trapping was made impossible. Again, the displaced trapper would have to buy fish or other protein, or accept a lower nutritional status.

Only two trappers engage significantly in production of handicrafts.

Most trappers gather fuel while at their trapping cabins and this must act as an energy subsidy. Its economic importance to the trappers is not known.

5.10 What Are the Feelings of Trappers Towards the Ontario Ministry of Natural Resources?

The Ontario Ministry of Natural Resources is in a key position to resolve conflicts between trappers and the logging industry so that it is important to understand the degree of co-operation between trappers and the ministry, and to have some feeling for the attitudes of trappers towards the government and its workers.

It was evident from the outset that most trappers are extremely wary of the government. (The authors were often perceived as agents

of the government and we received little co-operation until we could convince trappers that this was not so). The feelings of trappers towards government range from resignation to outright hostility (see appendix 12 for written opinions submitted by trappers). What are the reasons for this unwillingness to communicate openly? They seem to be :

1) That the Ministry of Natural Resources does not keep trappers informed of policy or solicit trappers' opinions on a regular basis. When trappers were asked if any government official had consulted them about logging practices or road building, only one replied 'Yes'. Twelve said that they had never been consulted, and six did not give an answer. The case of Mr. Bob Champagne, alluded to above, shows the worst consequences of such lack of consultation. It is understandable therefore that this question of consultation elicited strong comments.

   'We have solicited consultation and have been refused'.

   'To them (MNR) these people (trappers) are just peasants'.

   In fairness to the Ministry of Natural Resources one must state that serious efforts have been made to solicit public opinion in the SLUP process, but these have apparently not been successful as far as trappers are concerned.

2) Trappers are, by nature, an independent group.

3) There are communication barriers between MNR and some trappers because of language differences and illiteracy.

4) Trappers sometimes feel that they have to infringe government regulations to survive (e.g., shooting more than one moose in a season, or bait fishing with nets). This makes them very wary of anything which they perceive as surveillance.

On the positive side, the ministry runs workshops for trappers and some of the wildlife personnel have very good relationships with the trappers in their areas. The dichotomy between the wildlife personnel and the timber branch is apparent however, even in the field. One trapper remarked that:

> 'The logging and wildlife people just hate each other's guts'.

In various parts of northern Ontario it is obvious that the wildlife officers make numerous unofficial concessions to help the keener trappers. We have seen this done to ease the detrimental effects of logging, to help trappers with large families, and to aid those with less productive traplines. It is also obvious that some officers tacitly ignore some of those who break regulations because they know that to do otherwise would jeopardize these trappers' livelihoods. We have not documented these cases because we feel that to do so might hurt the interests of the individuals involved.

5.11 Conclusions

Trappers, as a group, are not against logging until it infringes on their own traplines. On the basis of this experience they develop strong sentiments against the logging industry. Their feelings towards logging roads are much more ambivalent and reflect a whole

complex of interactions. The Ministry of Natural Resources is not consulting trappers in any way about the effects of logging which include declines in several furbearer species and complications such as increased poaching. The trapper who leaves his trapline, or cuts down on trapping, loses income, protein nutrition and, in some cases, housing. Unofficial activities of wildlife officers have served to mitigate these effects in individual cases.

CHAPTER 6

DISCUSSION AND CONCLUSIONS

It has proven impossible to assemble time-series data showing trends in trapping harvests following logging of individual traplines. There are several alternative information sources however, which indicate that logging has a detrimental effect on trappers. The multiple regression data suggest that most of the upland furbearers have an affinity for mature forest stands rather than pioneer habitats. This is confirmed by previous studies (de Vos _et al_. 1959) and by the questionnaire responses of the trappers themselves. The second source is the rating of habitats provided by the trappers who were interviewed. This indicates that logged and burnt areas are of very little use to the trapper. The last information source is the questionnaire data which show that all trappers whose areas have been logged find that the process is detrimental to their livelihoods.

For large landscapes we have been able to demonstrate that the highest trapline productivity is likely to occur in an unlogged landscape with no fire control. With fire control, the trapline productivity of the whole landscape will fall slightly (in the order of 10 per cent), and the outcome in this case will not be very different from that with logging.

This last finding and those above seem to be at variance until one remembers that the effects on individual traplines are very

different from those on the whole landscape. Extensive logging on a single trapline can have a devastating effect as demonstrated by the low habitat rating of recently logged areas and the extent of such habitat after forest harvesting. It should be noted, however, that similar disruption of the trapper can follow a large fire.

The trapper whose area is heavily logged loses income, and food protein also. If he wishes to move his trapline he will probably find that his cabins, and other equipment, are less saleable because of the state of the trapline. The effects are demoralizing as judged by the questionnaire responses.

The effects of road building on trappers are complex, and we have not been able to investigate them adequately. Trappers' feelings towards road building are ambivalent. On the one hand, roads provide access to and from the trapline, but they also allow access to outsiders and thus encourage poaching and competition for fish and game. There is a further series of complex and subtle interactions involving roads. These concern schooling of children, availability of employment and other social matters. We have not been able to investigate them in any depth.

What are the trappers' reactions to these pressures? It seems that trappers prefer their work to any other occupation and few would readily change their lifestyle. The extent to which trappers seek employment in the logging industry is not affected by the logging of traplines, which is surprising considering the economic problems engendered by logging. Rather, many trappers try to obtain different

traplines which have not yet been logged, but in the past five years there have been few of these available. The remainder stay with their current traplines and presumably try to weather the problems that accrue.

There has been no government reaction to these problems. The Ontario government clearly regards the interests of the logging industry as automatically more important than those of trappers. It does not recognize the relationship between trappers and their forest environment as one which merits research and management, and it does not inform or consult individual trappers when their areas are to be logged. There is also little cooperation between the Division of Wildlife and the Division of Forestry on this matter. Some individual Ministry officials work hard to alleviate these problems, but as individuals they can achieve very little.

Trappers are ill-equipped to make their problems known at a political level. They are widely dispersed, lacking in formal education, often speaking little or no English, and their incomes are low. As a group, they are unlikely ever to have sufficient representation before the Ministry of Natural Resources, and this is further reflected by the apparently low status of the Furbearer Branch within the Wildlife Division of the Ministry.

In the light of the above, various management alternatives are available to avoid the worst effects of logging:

1) Abandon fire control. This might raise the trapline yield of the whole landscape marginally, but the effects on individual trappers whose areas are burnt would be as drastic, or more so than logging itself (cabins would be destroyed).

2) Maintain fire control without instituting logging. This would avoid the drastic local effects which occur with fire and logging, but would not raise the overall furbearer productivity of the landscape.

3) Limit the total amount of logging. This would probably be best applied to areas which are in any case marginal for forestry, and would necessarily be combined with more intensive management of areas close to existing mills. In particular, forest regeneration would need continuing, if not increasing attention (Suffling and Michalenko, 1980).

4) Operate a more dispersed pattern of logging which has less effect on individual traplines. This would require smaller logging camps, moved more often, and operating within smaller 'working circles'.

5) Offer trappers the option of logging their own traplines as a summer occupation. In this way they would remove a little mature timber each year without creating large areas of cutover land at any one time.

Option 1 is economically and socially unacceptable to most northerners, and would not be particularly desirable for trappers. The second option, of maintaining the status quo in unlogged areas, can only really be implemented in areas which have not yet been committed to forestry, and would be most appropriate in pockets of relatively unproductive land (in a forestry context) within the area under fire control. The third option of limiting the logged area may be feasible

in the long term but would be difficult to institute within the next few years because of the backlog in forest regeneration which has built up over the decades. Thus the fourth and fifth options offer the most immediate hope of alleviating some of the trappers' problems.

In summary, if nothing is done to buffer trappers from the biophysical effects of logging, it is unlikely that trapping as we know it can survive indefinitely within the zone of commercial forestry. The Ontario government has shown no interest in this problem even though it has the means to improve matters considerably. By its refusal to recognize a severe problem the government has adopted an implicit policy of slowly phasing out traditional trapping in favour of logging. This is neither beneficial nor necessary. (Recommendations are presented with the report summary on page ix).

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APPENDICES

APPENDIX 1

GLOSSARY AND SPECIES LISTS

GLOSSARY OF TERMINOLOGY AND ACRONYMS

Alder: Usually the areas along streams which grow thick shrubby areas of _Alnus rugosa_.

Barren and Scattered: Productive forest-land which, because of disturbance such as fire or logging contains only scattered trees (less than 25 per cent stocked), with no significant regeneration. Many areas so classified within the study area had been burnt and were in fact regenerating well.

Bog: Open muskeg.

Cluster Analysis: An objective mathematical method for ordering similar individuals with multiple attributes into groups. The output of the analysis is usually a hierarchical dendrogram resembling a family tree.

CCREM: Canadian Council of Resource and Environment Ministers.

CLI: Canada Land Inventory.

Dendrogram: See cluster analysis.

Discriminant Analysis: A statistical method which allows individuals to be assigned to pre-determined groups whose characteristics are known.

DLF: Department of Lands and Forests.

FAC: Fur Advisory Committee.

Forest Stand: An aggregation of trees possessing sufficient uniformity in composition, constitution, age, arrangement or condition, to be distinguishable from adjacent crops, so forming a silvicultural unit.

FRI: Forest Resource Inventory.

Group Threshold: The level of similarity in a dendrogram at which discrete groups are separated for further study. (see cluster analysis).

Line Transect: A line drawn across a piece of land or a map and used for sampling. The length of a certain type of vegetation covered by the line is usually taken as proportional to its area in the landscape.

Lowland: Those areas on organic soils (peat). They are generally poorly drained.

Marsh: Areas inundated for at least part of the year, with a vegetation of grasses and sedges.

Mature Stand: A stand of trees which has achieved maximum development and whose growth has begun to slow.

MNR: Ministry of Natural Resources.

Non-forested Land: Land not to be used for timber production. Included in this category, for the purposes of this study, as well are areas of rock and water.

Non-productive Forested Land: Land within a forested area which appears to be permanently out of the timber-producing class, owing to very low productivity.

OLI: Ontario Land Inventory.

OMNR: Ontario Ministry of Natural Resources.

Open Muskeg: Wet areas of mosses, grasses, sedges, and small shrubby on herbaceous plants, often interspersed with small areas of open water.

Pioneer: Refers to an ecosystem which arises early in succession (q.v.), following a disturbance such as fire or logging.

Productive Forested Land: All forest areas capable of growing merchantable timber and not withdrawn from such use.

RCNE: Royal Commission on the Northern Environment.

Regeneration: The process by which a forest is renewed (replaced) following disturbance. Alternatively the product of this process. To the forester, regeneration generally includes only those species which are useable commercially.

Regression Analysis: A statistical method for correlating one variable with one or more others by means of an equation. Where one 'dependent' variable is correlated with several others the method is known as 'multiple regression'.

Rotation:	The number of years required to establish and grow a timber crop to a specified condition of maturity.
Senescent Stand:	Refers to a stand of trees which is old and of diminished vigour. It may be subject to disease or windthrow.
SLUP:	Strategic Land Use Plan.
Stand:	An aggregation of trees possessing sufficient uniformity in composition, age, arrangement or condition to be distinguishable from adjacent stands.
Succession:	The process of ecosystem development involving changes in species composition and community processes over time.
Sustained Yield:	A management policy, plan or method of implying the highest practical continuous production of a natural resource in perpetuity.
Trapping Area:	The 'official' government trapline which may contain up to about 12 individual traplines.
Trapline:	The trapline of an individual trapper.
Treed Muskeg:	Muskeg with stunted trees as individuals, or in groups. Usually the trees are black spruce.
Upland:	Those areas on mineral soil.
Working Circle:	A division of a forest management unit for a specific reason which requires a calculation and allocation of the allowable cut separate from the calculation for the remainder of the management unit.

SPECIES LIST

MAMMALS CITED

Common Name	Latin Name	
American red squirrel	*Tamiasciurus hudsonicus*	Erxleben
Bear	*Ursus americanus*	Pallas
Beaver	*Castor canadensis*	Kuhl
Bobcat	*Lynx rufus*	(Schreber)
Coyote	*Canis latrans*	Say
Fisher	*Martes pennanti*	(Erxleben)
Fox	*Vulpes spp.*	Bowdich
Lynx	*Lynx canadensis*	Kerr
Marten	*Martes americana*	(Turton)
Mink	*Mustela vison*	Schreber
Moose	*Alces alces*	Linnaeus
Muskrat	*Ondatra zibethicus*	(Linnaeus)
Otter	*Lutra canadensis*	(Schreber)
Raccoon	*Procyon lotor*	(Linneaus)
Snowshoe Hare	*Lepus americanus*	Erxleben
Weasel	*Mustela spp.*	Linnaeus
White-tailed deer	*Odocoileus virginianus*	Zimmermann
Wolf	*Canis lupus*	Linnaeus
Wolverine	*Gulo luscus*	(Linnaeus)

VEGETATION CITED

Common Name	Latin Name	
Alder	*Alnus rugosa*	(Du Roi) Spreng
Aspen	*Populus tremuloides*	Michx.
Balsam fir	*Abies balsamea*	(L.) Mill.
Balsam poplar	*Populus balsamifera*	L.
Black spruce	*Picea mariana*	(Mill.) B.S.P.
Jack pine	*Pinus banksiana*	Lamb.
Tamarack	*Larix laricina*	(Du Roi) K. Koch
White birch	*Betula papyrifera*	(Marsh)
White spruce	*Picea glauca*	(Moench) Voss
Wild rice	*Zizania aquatica*	L.

APPENDIX 2

A REVIEW OF PREVIOUS FURBEARER HABITAT STUDIES

A literature search yielded several previous studies which attempted to establish relationships between furbearers and habitat. The majority of the studies were purely biological in nature in that they were concerned with variations in furbearer population densities rather than trapping returns. Also, most of the investigations were concerned with beaver. The following is a brief review of these studies and a summary of the implications of this previous work to the investigation.

This study takes a similar approach to that of the environmental impact studies for Quebec's James Bay Hydro project. Bergeron et al. (1976) for example, studied the relationship of habitat type (based on Jurdant et al.'s (1976) ecological classification system) and wildlife, including furbearers. Preliminary results indicated "interesting correlations" between species and habitat characteristics. Traversy (1976, 570) in studying beaver colony densities found more lodges towards the west. He attributed this trend to increasing habitat quality, specifically more streams and less rocky areas. Banville (1978, 22-23) in a similar study south of the Eastman River also concluded that variations in beaver colony density were mostly

attributable to habitat variation. He suggested that the abundance of slow moving streams and shoreline vegetation (especially aspen) were important beaver habitat variables.

Slough and Sadleir (1977) modelled the relationships between beaver colonies and habitat in British Columbia. Using a multiple regression analysis, lake and stream habitat models were developed. In both models food types explained the greatest proportion of the variability in the number of colony sites. Some of the other habitat variables that were found to be important were stream length, width, gradient, flow rate; lake perimeter, area, and water level stability. In total, the habitat variables in both the lake and stream models accounted for over 80 per cent of the variability in the number of colony sites.

A number of studies of furbearer/habitat relationships have also been conducted in Northern Ontario. Standfield (1958) found beaver colony densities to vary with forest types. In the Sioux Lookout area, forest stands composed of equal proportions of coniferous and deciduous species had the greatest beaver colony densities (Standfield, 1958, 39). In another study, Boultbee (1961, 9) found that beaver colony numbers were positively correlated with water occurrences in aerial surveys.

The studies noted above typify most of the furbearer/habitat research. In contrast, there have been a few Ontario studies which have investigated the relationships between trapping success and habitat. One of these was the work done by the Ontario Department of Lands and Forests between 1951-56, in the Gogama and Chapleau experimental traplines (De Vos and Crignan, 1959). This work is rare

in that it also looks at species other than beaver. Results indicated that fisher and mink were caught more often at trap sites along lakeshores (De Vos and Crignan, 1959, 28). Also, the capture of marten was found to be positively correlated with trap sites in mature coniferous forests.

The final study of interest (Standfield and Smith, 1971) looked at the relationship between beaver colony density and habitat in traplines in the Round Lake area of Northwestern Ontario. This study found no correlation between colony densities and food types (this contradicts the findings of Slough and Sadleir). On the other hand, the investigation did note that colony sites occurred principally in ponds, creeks and slow moving rivers. Lakes with low, sheltered shorelines were second in preference. Lakes with steep shorelines were infrequently colonized by beaver and fast flowing rivers had no colonies.

In summary, research of furbearer/habitat relationships has, with a few exceptions, been purely biological in nature. It has concentrated on beaver and has been primarily concerned with fluctuations in population density with respect to habitat. Few studies have looked at the importance of habitat to trapping success. Results from the Gogama and Chapleau experimental trapline, as well as the biological studies, indicate that investigations of this nature can be fruitful.

APPENDIX 3

THE DATA BASES:

THE IMPLICATIONS OF THEIR INADEQUACIES TO THIS STUDY

In the following discussion the inadequacies of the data sources, and their implications to this study, will be addressed. The approach taken to lessen any negative influences will also be discussed.

The Forest Resource Inventory Data

The forest resource inventory consists of maps and computer tape records of forest stand characteristics (see Dixon & Jenns, 1965, for a detailed description of data collection methods and the forest stand variables). In addition to the forest cover information, rivers, lakes, streams, areas of rock, open and treed muskeg, and brush and alder, are mapped in the FRI. These were the variables employed in the two habitat models. The remaining FRI variables such as timber volume, site class, and stocking, were not included as they were not expected to contribute new habitat information.

The primary concerns of this study were that the variables used in the habitat model were accurately measured. Despite criticism of the FRI's accuracy (Armson, 1976) it seems that most of the problems are primarily relevant to planning timber harvests. Field work in 1977 and a discussion of this matter with K. A. Armson,

indicated that the data were sufficiently accurate for use in this study (K. A. Armson, Pers. Comm., 1977).

One aspect of the FRI which required modification for this model was the treatment of non-forested and non-productive forested habitat. Lake areas and areas of open muskeg etc., are not recorded individually, as productive forest stands are, but are totalled for each township. In addition there is no tabulation of river or stream densities. Thus, these variables had to be estimated by sampling the FRI maps. The method employed is described in Appendix 7.

The date of the FRI survey (1965-1968) did not pose a problem in this study, because forest composition had not changed much in subsequent years. In addition, the data base had been updated to reflect any gross changes that did occur (D. Trafford, Pers. Comm., 1978).

The Fur Harvest Statistics

Records of furbearer pelts harvested on registered traplines have been maintained since 1947. Trappers are issued licenses and are required to have pelts sealed and recorded by appointees of the Ministry of Natural Resources. Trappers are also required to trap within specific licensed areas which were mapped by Ministry officials in co-operation with native representatives (Dunning, 1959, 27).

This data base is spatially and numerically more tenuous than the FRI because human factors play significant roles in the collection of fur harvest data (Rogers, 1966, 3). In an ideal model

of trapping success/habitat relationships one could identify all the components, both cultural and biological, and assess their relative importance, but the nature of the fur data and the practical constraints of this work dictated a more general conceptual approach.

Spatial definition of the actual habitat in which trappers trapped was crucial to the regression analysis (Appendix 4). There are three reasons why Ministry of Natural Resources trapping area maps did not permit this. First, trappers do not always trap their designated area (Watts, 1971, 66; Rogers, 1962, C26). This is not reflected in the fur returns as a trapper's harvest is always reported to his license and trapline number. Second, most MNR trapping areas have a number of trappers, and there is no way of determining which part of the area is used by each individual. A third problem is that trappers do not necessarily trap the same area from year to year, but may harvest several areas on a rotation basis (Rogers, 1962, C27).

These problems were solved by employing trapline maps compiled during a land use study conducted by Grand Council Treaty 9 in Northern Ontario. The maps (see Fig. A3.1 for an example) were compiled by asking trappers to indicate on 1:250,000 topographic maps, where they had trapped each year during their lives. They were also asked to draw in travel routes and indicate, using coloured dots, where they tended to catch different species. Although a boundary, often approximately the MNR official trapping area, was drawn around the points of activity the dot patterns showed that generally only parts of the area were being used for trapping at any particular time

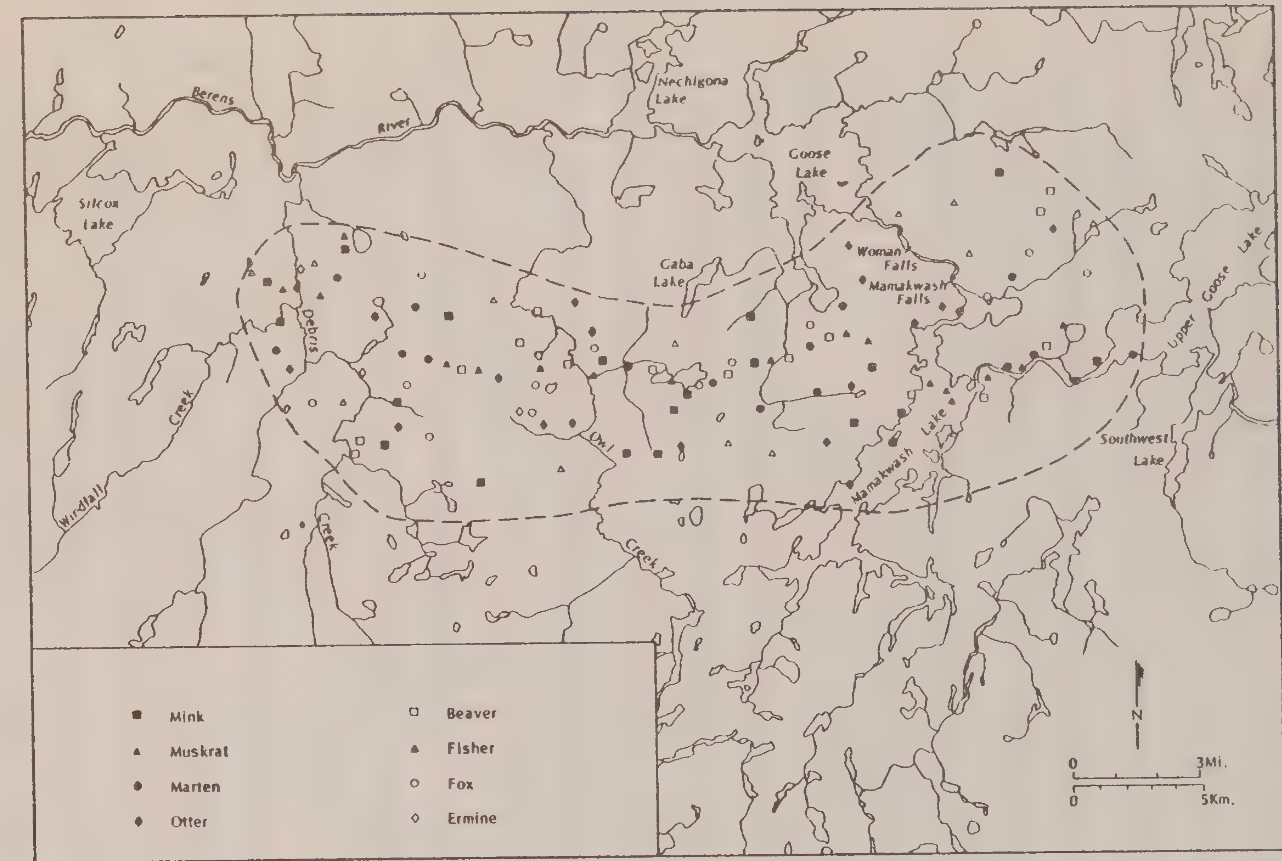

Fig. A3.1 A typical trapline map prepared from Treaty #9 Land use data, showing locations of species trapped.

(K. Siechiechowicz, Pers. Comm., 1979). This agrees with the findings of anthropological studies of communities in the study area (Rogers, 1962; Dunning, 1959). Thus the dots were employed to delineate the actual area being trapped. A trapping boundary was established by showing a band around the dots, as wide as the radius of a circle, whose area represented the largest range of the six mammals being studied. Fisher had the largest range, 10 square miles (Burt & Grossenheider, 1976, 54). Ideally, a separate boundary should have been drawn for each species, but this more general approach had to be taken.

The other advantage of using the Treaty 9 maps was that the trappers indicated the years in which they trapped an area. Consequently, areas that had been trapped for several years could be selected. Having a number of years of data allows one to average variations in harvests due to the natural population cycles observed in species such as mink and lynx. Thus, one criterion for the selection of trappers was that individuals had trapped the same area for at least four years. Also, only one area could have been trapped in the same year because harvests for different areas in the same year cannot be distinguished in the records.

Another inadequacy of the fur harvest statistics is that there is no record of the effort made by a trapper, e.g., the number of man hours spent trapping; the number of traps set; or his level of experience. Rogers (1966, 32), for example, found that more experienced trappers, those over 30, had larger harvests.

A questionnaire which is part of the land use study being

conducted by Grand Council Treaty 9, provided some direct and indirect clues for selecting trappers to minimize the effect of the above factors. The questionnaire supplied trappers' ages, years of trapping experience, whether all or part of a season was worked, and transportation technology used.

Another important factor that is not revealed in the fur returns is whether or not a trapper works alone or with friends or relatives. This is important because "men who trap together can stay away from the main camp longer and obtain more furs" (Bishop, 1974, 35). Fortunately the questionnaire also asked trappers to state who they trapped with. The sample was sufficiently uniform as all but one individual was assisted by others (Table A3.1).

One criticism of fur harvest data has been that trapper motivation is influenced by pelt prices which in turn affects harvest figures (Hurley, 1974, 2; Bailey, 1966, 6). But in studies of fur returns from Northern Ontario there was no correlation between price and number of pelts harvested (Rogers, 1966, 24-25; Watts, 1971, 84). Because of this and the fact that several years' data are being averaged, the effect of pelt prices is assumed to be insignificant for this study. The availability of alternative employment may also have an influence on the fur harvest.

Another possible problem is that a proportion of pelts are not sealed. Furs kept for personal use, sold to tourists or traded amongst trappers are not recorded in the harvest statistics (Bishop, 1974, 35; E. S. Rogers, Pers. Comm., 1977). Thus the statistics would tend to underestimate actual harvests. Although it was not

Table A3·1: Summary of Characteristics of Trappers Selected for Study[1]

COMMUNITY	TRAPPER	AGE	EXPERIENCE IN YEARS	PART OF SEASON SPENT TRAPPING	HELP ON TRAPLINE	TRANSPORTATION TECHNOLOGY[2]
CAT LAKE	1	46	28	all	relatives	1,2,3,4,5
	2	65	54	all	relatives	1,2,3,4
	3	43	26	all	relatives & friends	2,3,4
	4	39	29	all	relatives	all
	5	31-46	15-24	all	relatives	all
	6	52	40	all	no help	all
	7	N/A[3]	at least 54[4]	N/A	relatives	N/A
PIKANGIKUM	8	65+	50+	all	relatives	all
	9	31-40	at least 27	all	relatives	4,5
	10	65+	55+	all	relatives	all
	11	21-30	N/A	N/A	N/A	N/A
	12	47	35	all	relatives	2,3,4,5
OSNABURGH	13	41-50	25-34	all	relatives & friends	2,3,4
	14	51-65	31-45	all	friends	N/A
	15	N/A	at least 54	all	relatives	1,3

[1]Source: Grand Council Treaty 9 Land Use Study.

[2]Transportation Technology: 1 dog team
2 airplane
3 snow shoes
4 canoe
5 snowmobile

Employed for all or part of the study period.

[3]N/A - this portion of questionnaire not answered.

[4]estimated from dates given on land use maps.

APPENDIX 4

STEPWISE MULTIPLE REGRESSION ANALYSIS OF THE INFLUENCE OF HABITAT ON TRAPLINE HARVESTS

Introduction

In this appendix, fur harvest and habitat data are subjected to a regression and correlation analysis to see which habitat variables have most effect on the fur harvest. The step-wise multiple regression and correlation program BMDP2R (Dixon, 1977, 399) is the technique employed.

Method

Step-wise regression is a version of multiple regression in which independent variables are entered into the regression equation one at a time, in order of importance. That is, the variable with the highest correlation with the dependent variable is entered first, followed by the other independent variables in descending order of correlation (see Draper and Smith (1966) for a more detailed discussion of this technique). The inclusion of variables stops when none of the remaining variables will add a statistically significant increase to the level of explanation of the regression equation.

There are several advantages to the step-wise approach. First, the number of independent variables in the regression equation is minimized. With fewer variables it is easier to interpret the meaning

possible to determine the size of this error, it was assumed to be small. (This was confirmed by our own questionnaire. See Chapter 5). This is because the importance of barter has diminished among native trappers since the adoption of the money economy (Bishop, 1974, 23-30).

Although it was not possible to quantify these human factors individually and thus to gauge their relative importance, their combined influence could still be estimated. It is expressed as part of the residual variation (unexplained variation) of the regression model.

of the equation. Second, the step-wise approach allows an assessment of the relative importance of each variable as indicated by their order of inclusion. Third, redundant explanation is avoided because only those variables which account for a significant amount of remaining, unexplained variation are added to the regression. Last, this method helps avoid the potential computational problem of matrix singularity that arises wherever the number of independent variables equal or exceed the number of observations (G. Benett, Pers. Comm., 1979).

Certain assumptions are made in regression analysis so that the statistical significance of the results can be assessed. It is assumed that the error components (residuals) are independent, have a zero mean value, a constant variance, and follow a normal distribution (Draper & Smith, 1966, 86). The validity of these assumptions was assessed by examining plots of the residuals against the predicted trapping success (Fig. A4.1), and on normal probability graphs (Fig. A4.2) the residuals will form a straight line if normally distributed. In addition, residual patterns can indicate the lack of a linear relationship. This is important because multiple linear regression assumes that the dependent variable can be explained by a linear combination of the independent variables. The plots can also indicate what type of modifications should be made to the equation to provide a better fit (Draper & Smith, 1966, 86-91). Examination of the various plots suggested that the previous assumptions were not violated for any of the regressions.

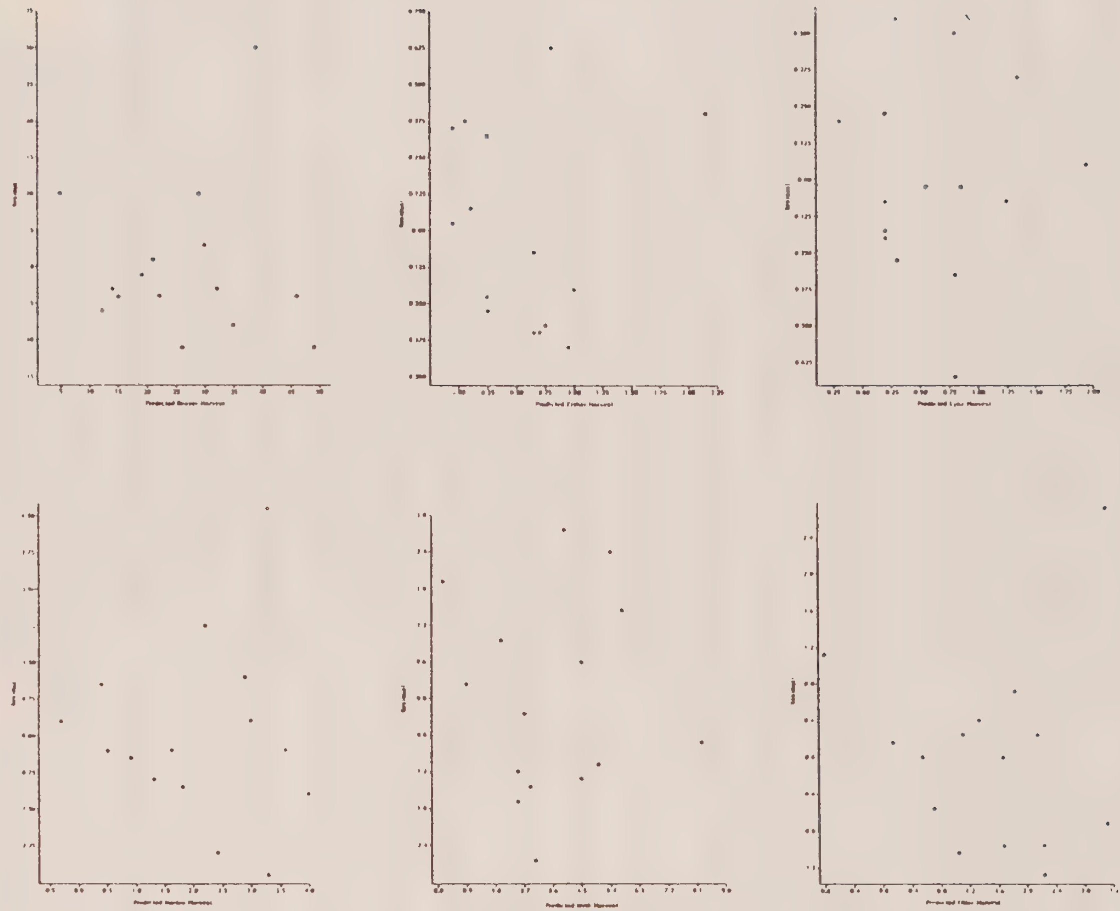

Fig. A4.1 Plots of residual error against predicted fur harvest calculated by multiple regression. Lack of a trend in the scatter of points indicates that the residual error is independent of the variables used in the regression.

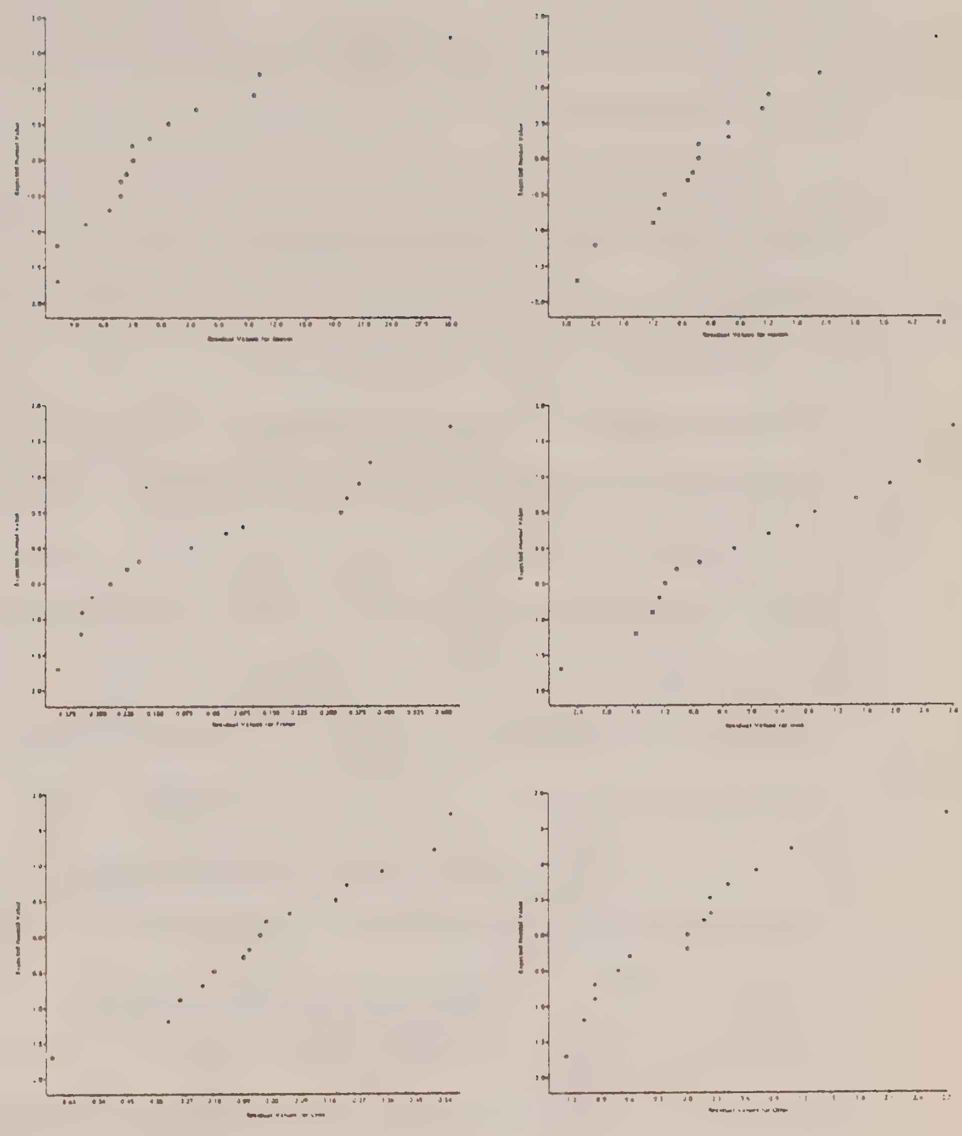

Fig. A4.2 Normal probability plots of the multiple regressions of fur harvest. The scatter should follow a straight line if the data are normally distributed.

Discussion of Results

The results of the initial set of regressions are summarized in Table A4.1. All the regression equations were proven statistically significant when the calculated F-ratios were compared with those of the F distribution.

The amount of variation in trapping success explained by the habitat variables varied from a high of 75% ($R^2 = 0.7486$) for lynx trapping, to a low of 33% ($R^2 = 0.334$) for marten trapping. With the exception of marten trapping, the proportion of the total variation explained was in the order of 50% in all the regressions. Besides the R^2 values, plots of the predicted values of trapping success versus the observed values (Fig. A4.3) were used to help manually assess the predictive value of the equations. Perfect prediction would be indicated by the data points falling in a straight line of slope + 1.0 (45°). In most of the scatter plots the data points can be fitted with a straight line. The points for marten trapping are widely scattered, as reflected in the low R^2 value and thus in the low level of explanation of the regression equation. Fisher trapping, on the other hand, has a relatively high R^2 value (0.7423), but the scatter plot shows that all the points, except one, cluster in the bottom left corner of the graph.

Table A4.1: Summary of Results for Initial Regression Analyses

Species	Step	Variable Entered	Multiple R	Multiple R^2	Increase in R^2	F to Enter	Final Regression[1] Coefficient	Residual Sum of Squares	Partial Correlation	Overall F Ratio	Table[2] F Ratio
Beaver	0							3769.84		8.84	
	1	Group 18	0.6106	0.3619	0.3619	7.3736	-0.0043	2405.46	-0.60160		
	2	Treed Muskeg	0.7719	0.5958	0.2339	6.9445	0.0013	1523.69	0.60545		3.89
Mink	0							95.53		9.51	
	1	Open Muskeg	0.6742	0.4545	0.4545	10.8332	0.0015	52.11	0.67420		
	2	Brush & Alder	0.7831	0.6132	0.1587	4.9231	0.0003	36.95	0.53936		3.89
Marten	0									6.53	
	1	Open Muskeg	0.5783	0.3344	0.3344	6.5308	0.0014	47.60	0.57286		4.67
Otter	0							30.98			6.52
	1	Group 18	0.5774	0.3334	0.3334	6.5022	-0.0004	20.65	-0.57741		
	2	Open Muskeg	0.7217	0.5208	0.1874	4.6943	0.0007	14.84	0.53028		3.89
Fisher	0							6.16		10.56	
	1	Group 2	0.6635	0.4402	0.4402	10.2226	0.00001	3.45	0.66348		
	2	Group 71	0.7780	0.6053	0.1651	5.0199	0.0021	2.43	0.54309		
	3	Brush & Alder	0.8616	0.7423	0.1370	5.8456	0.0001	1.59	0.58908		3.59
Lynx	0							60.0		10.92	
	1	Rock	0.6919	0.4788	0.4788	11.9402	0.0001	3.13	0.69192		
	2	Group 18	0.9029	0.6447	0.1660	5.6059	0.0001	2.13	0.56428		
	3	Group 71	0.8652	0.7486	0.1039	4.5463	-0.0018	1.51	-0.54077		3.59

[1] Final regression coefficient once stepping is completed.

[2] x = .05, degrees of freedom for numerator = # of independent variables (IV)
degrees of freedom for denominator = 15 - (IV+1).

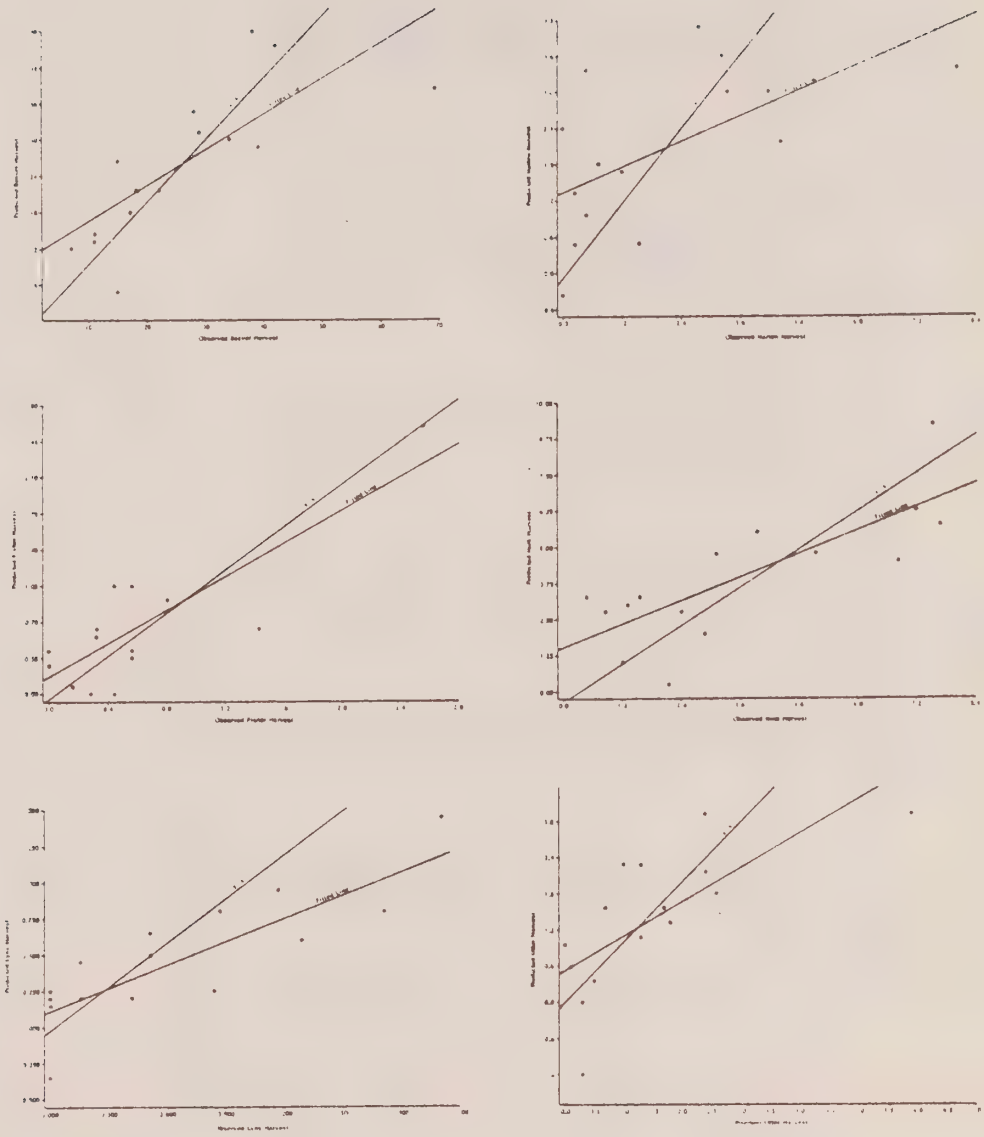

Fig. A4.3 Plots of fur harvests predicted by multiple regression, against observed harvests. The observed and predicted values should ideally coincide along the lines marked y = x. The fitted lines are linear regressions of the data.

Thus the one relatively large observed value (top right corner) essentially determines where the prediction line will fall. The lack of intermediate points suggest that this model is rather tenuous as far as predictive value is concerned. This situation will be addressed in more detail in the discussion of the residual errors.

In all of the above plots the slopes of the fitted lines were substantially less than one. This graphically illustrates the moderate level of explanation that the multiple regression equations offer. Discussion of the practical significance of these results will follow.

Examination of the plots of the residuals against predicted trapping success (Fig. A4.1) did not reveal any obvious patterns that would suggest a need for more terms in the regression equations, or transformations of the data. But, outliers were present in 4 of the regressions, one each for beaver, marten, otter and fisher. This is important because outliers represent atypical observations in the data, and thus should be examined to determine the reason(s) for their peculiarity. If the outliers can be traced to errors in measurement they can be rejected and the regression rerun without them. Otherwise, they represent observations which arise from unusual combinations of circumstances which may be of vital interest.

The outliers observed for beaver, marten, and otter (residual values of 30.0, 4.6, and 2.7 respectively), were traced to trapper #2 (Table A4.1). The outlier for fisher trapping success (a residual of 4.0) was traced to trapper #1. Because of the relatively small sample of trappers and the nature of the fur harvest data these outliers presented

a dilemma. Trapper #2 is an interesting example: is his superiority in trapping three species due to an unusual abundance of good habitat in his area, or, is it because of other factors such as the use of his license by others to record their catches? These are both plausible reasons for outliers. A larger sample of and a more detailed profile of trappers would have helped determine which of the factors was responsible. Neither of these solutions could be adopted because of practical constraints, or shortcomings in the data.

It was decided, therefore, that the best way to deal with the outliers was to assess their influence on the regression equations, the rationale being that if there was little or no influence the presence of outliers and the effects of the relatively small sample size could be ignored. This was done by running three more sets of regressions: omitting trapper #1, then #2, then both from the calculations. The results of these analyses were then compared with the initial regressions. There are two advantages to this approach. First, one can note the changes in R^2 and the variables entered into the regressions, and thus assess the relative importance of these extreme values to the type of regression equation produced. Second, because the trappers are also removed from regressions in which they were not outliers, the stability of the regression with respect to the overall sample size can also be assessed. The results of all four sets of regressions are compared in Table A4.2.

The results for the beaver trapping success indicate that the removal of observations substantially changed the nature of the

Table A4.2: Sensitivity of Regression Analyses to Removal of Individual Observations

Species	Step	Initial Analysis: Variable Entered	Initial Analysis: Multiple R^2	Trapper 1 Removed: Variable Entered	Trapper 1 Removed: Multiple R^2	Trapper 2 Removed: Variable Entered	Trapper 2 Removed: Multiple R^2	Trappers 1 & 2 Removed: Variable Entered	Trappers 1 & 2 Removed: Multiple R^2
Beaver	1	Group 18 (-ve)[1]	0.3619	Group 18 (+ve)	0.3280	Water (+ve)	0.4007	Rock (-ve)	0.4926
	2	Treed Muskeg (+ve)	0.5958	Brush & Alder (+ve)	0.6582	Group 18 (-ve)	0.7229	Permanent Streams (-ve)	0.7250
	3			Open Muskeg (+ve)	0.8132	Treed Muskeg (+ve)	0.9067	Group 71 (-ve)	0.8191
	4			Group 8 (-ve)	0.8930				
Mink	1	Open Muskeg (+ve)	0.4545	Open Muskeg (+ve)	0.3943	Water (+ve)	0.5579	Water (+ve)	0.5621
	2	Brush & Alder (+ve)	0.6132					Group 18 (+ve)	0.7425
	3							Lakeshore (-ve)	0.8243
Marten	1	Open Muskeg (+ve)	0.3344	Brush & Alder (+ve)	0.3603	Water (+ve)	0.7424	Water (+ve)	0.7288
	2			Open Muskeg (+ve)	0.5955	Brush & Alder (+ve)	0.8250	Brush & Alder (+ve)	0.8510
	3							Barren & Scattered (-ve)	0.9003
	4							Treed Muskeg (-ve)	0.9338
	5							Permanent Streams (+ve)	0.9805
	6							Group 18 (+ve)	0.9914
Otter	1	Group 18 (-ve)	0.3334	Group 18 (-ve)	0.3132	Group 18 (-ve)	0.3746	Rock (-ve)	0.3260
	2	Open Muskeg (+ve)	0.5208	Open Muskeg (+ve)	0.5272	Group 31 (+ve)	0.7010	Lakeshore (-ve)	0.6812
	3					Water (+ve)	0.8507	Wide Streams	0.7842
	4					Group 8 (-ve)	0.9417		
	5					Group 71 (+ve)	0.9716		
	6					Brush & Alder (-ve)	0.9849		
Fisher	1	Group 2 (+ve)	0.4402	Group 71 (+ve)	0.2676	Rock (+ve)	0.4479	None	--
	2	Group 71 (+ve)	0.6053	Group 2 (+ve)	0.5079				
	3	Brush & Alder (+ve)	0.7423						
Lynx	1	Rock (+ve)	0.4788	Rock (+ve)	0.3494	Rock (+ve)	0.6904	Rock (+ve)	0.6280
	2	Group 18 (+ve)	0.6447	Group 18 (+ve)	0.5764	Group 18 (+ve)	0.7855	Treed Muskeg (+ve)	0.7796
	3	Group 71 (-ve)	0.7486	Open Muskeg (+ve)	0.7304	Group 71 (-ve)	0.8471		
	4			Group 71 (-ve)	0.8541				

[1] +ve (positive), -ve (negative) show the relationship between the dependent and independent variable.

regressions. In all the new equations the explained variation increased to over 80%. The removal of trapper #2 increased the R^2 to 0.8967 from the previous 0.5958. An unexpected result was the similar increase in R^2 that occurred when trapper #1 was removed. A possible explanation is that trapper #1 is the second most productive trapper. Thus, it seems that the weighting effect of these two successful trappers produces a regression line with a poorer overall fit. This conclusion is supported by the fact that the R^2 remains high (0.8191) after the trappers are both removed.

In addition to the change in R^2, the number and type of variables in the equations also changed with the removal of observations. The number of variables increased in all of the new regressions. Group 18 (poplar dominated stands) remained negatively correlated through the first three regressions, but was not included in the fourth equation. It was expected that this variable would be positively related to beaver trapping success as poplar is an important food. But examination of the F.R.I. maps revealed that this type of forest stand tended to occur away from water. Thus it may be that this variable is indirectly reflecting the importance of aquatic habitat. The inclusion, and positive correlation of aquatic habitat variables such as brush and alder (these are also food sources found on stream banks), treed muskeg, open muskeg, and water in the various equations tend to support this conclusion. Also, this agrees with Standfield and Smith's (1971, 59) observations that "there is a decided preference for certain physical qualities of water which may override the relative availability of food."

In the fourth regression the equation includes a completely different set of variables. The negative correlation of beaver trapping success with area of rock is quite reasonable, as rock outcrops tend to be more common in upland areas. The negative correlation of permanent streams, on the other hand, is contrary to what one would expect. A rational explanation for this was not evident.

In summary, it is apparent that the regression equations for beaver trapping success are not very stable with respect to the number and type of variables included and level of explanation produced when outliers are removed. Although most of the equations can be rationally explained in terms of the habitat requirements noted in the literature, their instability leads to the conclusion that the initial regression is of little predictive value. Also, it may be that at high levels of trapping success the relationship with habitat becomes non-linear. This is suggested by the increase in R^2 that occurs when the highly productive trappers are dropped from the analysis. Unfortunately there are not enough highly productive trappers in the sample to explore this possibility. In general, there does seem to be a relationship between beaver trapping success and the habitat variables selected. But further study with a larger sample of trappers is necessary before the regression can be considered entirely reliable.

The effect of removing observations from the analysis are somewhat different for mink. Open muskeg, and, brush and alder were the variables included in the initial equation. They were both positively correlated with mink trapping and explained 63% of the

variation in trapping success. Both these variables are indicative of the water land interface that mink prefers (de Vos and Crignan, 1959, 29) and so their inclusion in the equation is reasonable. The removal of only trapper #1, or #2, reduced the R^2 value to 0.3943 and 0.5579 respectively; also only one variable was included in each equation. The removal of both trappers increased both the R^2 (to 0.8243) and the number of variables (to three) in the equation. Unlike the two previous regressions, the correlations in this one seemed less plausible.

The negative correlation of the lakeshore variable and the positive correlation of group 18 (which as mentioned previously could indirectly be representing the absence of water) contradict the findings of biological studies of mink habitat preferences. The interpretation of these results are similar to those for beaver. Again it can be concluded that the regression is not very stable; in this case this may even be more signficant as there were no observable outliers. The results of the initial and two of the subsequent regressions did suggest a reasonable relationship between the data, which again would merit further investigation with a larger sample.

Examination of the initial and subsequent regressions for marten trapping revealed a completely unexpected set of correlations. Marten prefers mature coniferous forest (de Vos and Crignan, 1959, 29; Francis and Stephenson, 1972, 35-38); in this area this would be primarily stands of jack pine or spruce. None of the group classes with these species were included in the regression equations. Instead, indicators of aquatic habitat such as open muskeg and brush and alder

were included, and were positively correlated. The removal of outliers did not change the type of variables in the equation, but did increase the R^2 value. Because of these results it must be concluded that the data at hand did not suggest a reasonable relationship between marten trapping success and the habitat classification. It may be that ease of trapper access to uplands is heavily correlated with aquatic habitats and the marten catch reflects this.

The results of the regressions of otter trapping success and habitat are similar to those for beaver in terms of the variables included in the regressions. But in this case the removal of the outlier resulted in distinctly different regression. The initial regression equation explained 52% of the variation in trapping success. It was negatively correlated with poplar stands (group 18), positively linked to open muskeg. These results are reasonable from a biological point of view as otter prefers aquatic habitat (Burt and Grossenheider, 1976). Removal of trapper #1 did not alter the nature of the equation. On the other hand, removal of trapper #2 resulted in one R^2 of 0.9849 and the inclusion of 5 new variables. In addition, open muskeg was dropped from the equation. Of the variables included brush and alder and group 71 (characterized by white spruce) showed negative and positive correlations respectively. The opposite would have been expected given personal knowledge on otter habitat. The last regression introduces three different variables; work, lake shore, and wide streams. As with the previous fur bearers, it must be concluded that the equation is not sufficiently

stable to make strong conclusions about the relationship between otter trapping success and habitat. Again, the number of observations seem to be a limiting factor. Although, like beaver, the initial regressions showed some reasonable relationships.

The testing of the fisher trapping success regression also indicated an unstable equation. Removal of the outlier resulted in a lower R^2 and the loss of one variable. Surprisingly, the removal of trapper #2 had an even greater effect on the R^2 and the inclusion of variables (see Table 9). When both trappers were removed a statistically significant equation could not be constructed. Figure graphically illustrates the tenuous nature of the initial equation, as there is an obvious lack of intermediate data points to define the regression equation. Thus, it must again be surmised that more observations are required before any definite conclusions can be made about trapping success and habitat for this species.

The testing of the lynx trapping success equations yielded much more stable results than that for the previous species. All three of the variables in the initial equation were retained when each of the selected trappers were removed. In addition, the degree of explanation remained fairly constant in each equation. Figure A4.3 shows how well the predicted and observed values correspond across the full range of values. The type of variables included, on the other hand, do not entirely represent what one would expect for this species. Group 18 (poplar) and 71 (white spruce) respectively show positive and negative correlation with trapping success. One would expect the reverse as lynx tends to prefer dense climax boreal forest (Burt & Grossenheider, 1976). Similarly, rock shows a strong positive

correlation with trapping success for this species. A possible explanation for this is that as far as trapping success is concerned, the accessibility of lynx habitat is more important than the actual amount of habitat. The above variables and correlations tend to suggest that more lynx are caught in trapping territories which have large amounts of open space, e.g., areas of rock or more open vegetation. These conditions would allow better access, by skidoo etc., to inland areas (most trapline routes follow lakes and rivers). This is advantageous to lynx trapping as these areas tend to be less disturbed, and are more likely to offer a different type of habitat than that encountered along river or lake routes.

In summary, the analysis of the lynx trapping data produced mixed results. The regression equation was stable, but the correlation with the independent variables were contrary to what would be expected. These results suggest further study of the importance of interior accessibility to lynx trapping, and a testing of the equations' predictive powers on trappers not used in this study.

Summary and Conclusions

In general, the previous analyses were unsuccessful in attempting to reveal numerical relationships between trapping success, as measured by the fur harvest data, and, trapping area habitat, as quantified by the habitat classification scheme. None of the equations reveal any information about logged areas since none of the trappers whose trapline boundaries were accurately known had experienced any logging. The investigation of lynx trapping yielded the only regression model that was stable enough to merit more detailed study. The type of independent variables, and their correlations in the lynx equation strongly suggested

that trapping of some furbearers is based on a complex relationship between the effect of habitat on furbearer numbers and its influence on trapper behaviour. Terrain may influence trapping strategy significantly and thus play an important role in determining trapping success.

The instability of the rest of the regression equations essentially limits the interpretation of the analyses to diagnosing the reasons for these results. For the examples in which the equation changed when a "normal" observation was removed, it is possible that more observations are needed before a consistent equation is produced. Another possibility is that the relationships being studied are not linear, in which case the removal of observations, both outliers and "normal" values, would tend to be of greater consequence to the regression equation. Investigation of non-linearity would only be worthwhile with a larger sample of trappers to ensure the existence of a definite pattern. It would also be advantageous to employ a stratified sampling strategy to ensure proportionally adequate representation of different levels of trapping success. Closely associated with this is the importance of being able to attribute outliers to measurement error, or genuinely unusual circumstances. As was previously mentioned, this could not be done in this study because of insufficient information on the trappers.

In general, it is felt that the inconclusive results of the regression analysis are not, for the most part, attributable to short-

comings in the classification and quantification of habitat. It is more likely that the necessarily crude method of selecting trappers did not screen out unwanted sources of variation. In any case, there is an obvious need to further assess the fur harvest data as a measure of trapping success.

APPENDIX 5

THE CLUSTER ANALYSIS METHOD

A number of different approaches are available in cluster analysis. Groups can be selected on one (monothetic) or several (polythetic) characteristics. Also, the grouping process itself can either involve comparing a number of individuals and fusing similar ones into groups (agglomerative grouping), or dividing one large heterogeneous group into a number of smaller homogeneous groups (divisive). The relative merits of these approaches have been discussed by Frenkel and Harrison (1973), Sokal and Sneath (1973) and Wishart (1975). After considering this information, a polythetic agglomerative technique, H Group (Veldman, 1967, 308), was selected because it produces statistically "tight" (Wishart, 1975, 11) groups and suits the data in this study.

The number of individuals that could be grouped using cluster analysis was limited by computer memory capacity. This required the selection of the smallest possible representative sample from the population of 43,506 forest stands. Successive samples of diminishing size were randomly selected from the entire study area so that the full range of species composition would be represented. Representativeness was assessed using the Kolmogorov-Smirnov test (Siegel, 1956, 47-52) for goodness of fit (Table A5.1).

Table A5-1: Results of Kolmogorov-Smirnov[1] Goodness of Fit Test

TREE SPECIES	D[2]	p[3]
Jack pine	0.030	0.20
Black spruce	0.030	0.20
White spruce	0.009	0.20
Balsam fir	0.008	0.20
Tamarack	0.003	0.20
Poplar	0.002	0.20
White birch	0.001	0.20

x = 0.05

1. For a detailed description of this test see Siegel, 1956, pp. 47-60.

2. D=maximum deviation between the sample and population cumulative frequency distributions.

3. p is the probability under H_o of the occurrence of a D value greater than or equal to the calculated D value.

Note: In all cases p was greater than 0.20 since this does not fall into the rejection region defined by alpha = 0.05 the H_o must be accepted and it can be concluded that in terms of species composition the sample is representative of the population.

This non-parametric technique was used because the data failed to meet the assumptions of the usual parametric tests. In addition, this test employs frequencies rather than means, and thus uses more information in its assessment of goodness of fit. It should also be noted that the testing was simplified by having the actual statistical characteristics of the population at hand. A 279 forest stand sample emerged as the smallest representative group that could be submitted to cluster analysis.

Each character variable is equally important in H Group, in determining similarity between groups and individuals. Thus if species variables show a large range of variances, as in this study, those with extreme variances will tend to dominate the analysis (Veldman, 1967, 311; Wishart, 1975, 17). This problem was solved by standardizing the data prior to clustering (see Noy-Meir et al., 1975 for detailed discussion on the effects of standardization).

A skree plot, Figure A5.1, was used to determine the most reasonable level of grouping. The grouping error was plotted against the number of groups for the 2 to 25 group levels. From the graph it is clear that the error begins to increase significantly near the nine and ten group levels. Thus, any further amalgamation would introduce much more heterogeneity in the groups. The nine group level was selected as the grouping threshold.

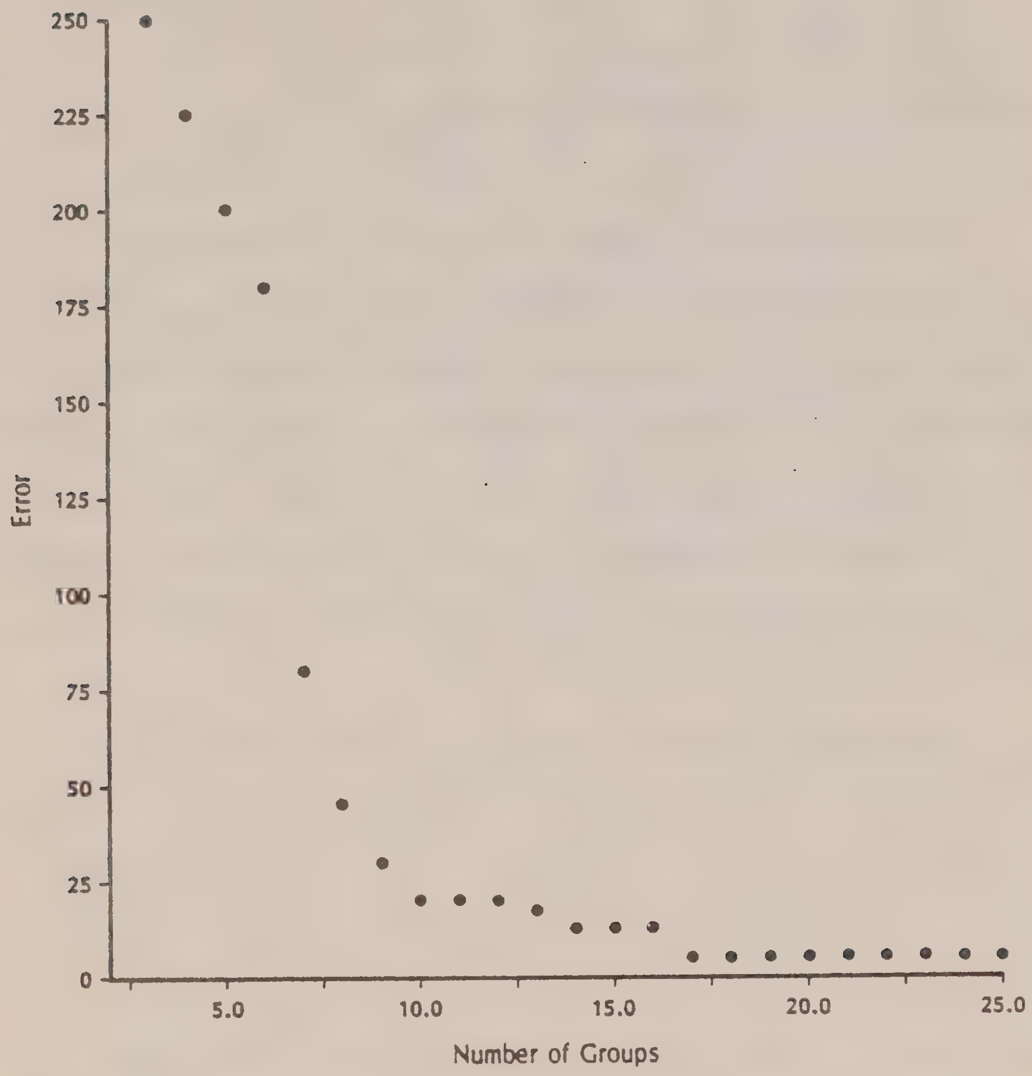

Fig. A5.1 Skree plot of error against number of groups selected in the cluster analysis of forest stands. The break in the trend around the 10 group level indicates where further amalgamation leads to large increases in error. This was taken as the group threshold (Fig. 3.3).

APPENDIX 6

EVALUATION OF STATISTICAL AND ECOLOGICAL VALIDITY OF FOREST TYPE GROUPS CHOSEN BY CLUSTER ANALYSIS

The validity of the groups was assessed in two ways: statistically, by applying discriminant analysis, and practically, by comparing them with known ecological types.

Discriminant analysis was used because misclassification of individuals by clustering procedures is not uncommon. Although H Group produces "tight" homogeneous groups, one cannot evaluate the probability of an individual belonging to a group during the analysis. Thus, as clustering goes beyond joining individuals, and begins to link groups, marginal members of a newly formed group may have more in common with another group. The application of discriminant analysis reveals such misclassifications.

When using discriminant analysis one must assume that the discriminating variables are from a normally distributed population and have equal variance/co-variance matrices within each group (Klecka, 1975, 434). In addition, one must be confident in the ability of the discriminating variables to define distinct groups. Only the last assumption was satisfactorily met by the data.

Klecka (1975, 435) suggests that in practice the technique is very 'robust' and thus that the assumptions of normality and equal variance need not be strongly adhered to. Since a consensus on what robustness is has not as yet been reached (Mitchell, 1974, 523)

among statisticians, an additional strategy was adopted to ensure confidence in the results of the discriminant analysis (the suggestions of G. Benett were greatly appreciated in this matter).

The discriminant procedure adopted was as follows: the validity of the groups was evaluated using stepwise multiple-discriminant analysis, listed as BMDP07M (Dixon, 1977, 711). Individuals, misclassified by cluster analysis, were reassigned to groups for which they showed stronger affinity. The results of the analysis indicated that only 9 (3 per cent of the 279 stands classified forest stands) were misclassified; see Table A6.1 for a summary of the misclassifications. This meant that the cluster analysis was quite acceptable. The misclassified stands were then assigned to their new groups (see Table A6.1 for new groups), and the discriminant analysis was rerun to see whether reassignment led to further misclassification. No misclassifications resulted. The group's species composition was calculated and the results are presented in Table 3.1.

Validity of the discriminant analysis was ascertained in two ways. The first approach was to randomly remove 55 of the 279 individuals from the groups. They were then treated as unclassified individuals (externals) in another discriminant analysis. In this new analysis, these externals were then to be classified into the existing groups by a new set of discriminant functions that were based on the remaining data. The results were then compared with those of the original analysis. If there were large discrepancies in group affiliation for the 55 externals (when compared to their previous groups), and many new misclassifications for the remaining

Table A6.1: <u>Misclassified Forest Stands</u>

	MISCLASSIFIED			RECLASSIFIED			% SPECIES COMPOSITION						
STAND NUMBER	ORIGINAL GROUP	MAHALANOBIS D^2 (2)	POSTERIOR PROBABILITY (3)	NEW GROUP	MAHALANOBIS D^2	POSTERIOR PROBABILITY	JACK PINE	BLACK SPRUCE	WHITE SPRUCE	BALSAM FIR	TAMARACK	POPLAR	WHITE BIRCH
203	2	31.2	0.009	1	21.9	0.991	0.4					0.2	0.4
122	5	4.9	0.489	8	4.8	0.511	0.1	0.8				0.1	
178	5	9.9	0.305	8	8.3	0.695		0.8					0.2
275	5	8.7	0.453	8	8.3	0.547		0.8				0.2	
52 (1)	5	268.2	1.000	16	1087.2	0.000		0.9			0.1		
74	8	5.1	0.474	5	4.9	0.526	0.2	0.8					
175	8	5.1	0.474	5	4.9	0.526	0.2	0.8					
177	8	5.1	0.474	5	4.9	0.526	0.2	0.8					
128	18	22.2	0.112	2	19.0	0.576	0.4	0.3				0.3	

[1] It was felt that this stand belonged in group 16, (despite the higher D^2 and lower posterior probability for that group) because of the presence of tamarack. The results of the next step in the analysis supported this decision as the D^2 and posterior probabilities now favored membership in group 16.

[2] Mahalanobis D^2 is a measure of the distance of an individual from the group mean (Dixon, 1977, 177).

[3] The posterior probability is the likelihood that a case would be observed this distance from the group mean (Dixon, 1977, 718).

individuals, it would suggest that the discriminant analysis was too susceptible to random data variations, and thus could not be trusted.

This was not the case, since the results of the test supported the validity of the original discriminant analysis. All 55 externals were assigned to the same groups they had previously occupied. Only one misclassification (Stand 52) resulted among the remaining individuals. This stand (90 per cent black spruce and 10 per cent tamarack) had previously been forced from group 5 to group 16 because it contains tamarack (see note Table A 6.1). The test analysis was now suggesting that it belonged in group 5. This result was ignored as the stand obviously belonged in group 16, but it did suggest that similar stands might be improperly assigned to group 5 in future analyses. Thus, precautions were taken to detect this error in the subsequent classification of trapline forest stands.

The second test of the discriminant analysis was the classification of a large random sample of stands for the study area. Numerous misclassifications would suggest that the discriminant functions do not adequately separate the groups. The criterion for identifying a misclassified individual was the possession of an abnormally large Mahalanobis D^2 or an abnormally small posterior probability for its assigned group (abnormality was subjectively assessed and based on the range of values observed in the group in question). In addition, a common pattern of species composition in the misclassified individuals would indicate the presence of a new group. This would then require an additional group in the classification scheme.

Of the 836 stands randomly selected for classification, only 52 (5%) were considered misclassified. No discernible pattern was observed in the misclassifications and the stands were easily reassigned to existing groups. In summary, the results of the tests supported the discriminant analysis. Thus, statistically speaking, the classification produced by the cluster analysis was a valid one.

The ecological evaluation of the cluster analysis was based on a comparison of the classification with other ecological forest type classifications produced by foresters. Two such classifications exist for the study area. Buys (1961, 8) identifies 5 forest subtypes in the area while the Forest Resource Inventory recognizes 7 major forest working groups in the area. These two classifications and the derived classification are compared in Table A6.2 The cluster analysis groups corresponded quite well with FRI working groups. Examination of FRI data, for forest stands classified by cluster analysis, showed an almost exact correspondence between working group and cluster analysis group. Only one working group class, Balsam fir, did not have a corresponding cluster group. This was not considered significant as only 141 stands in the entire study area belonged to this working group. A more important difference noted in the comparison is the greater sensitivity of the derived classification in further separating stands dominated by black spruce. These "subtypes" reflect the wide variety of habitat in which black spruce can be found. Black spruce-Jack pine is found predominantly in dry upland sites, while pure Black spruce is most commonly found in low wet areas (Fowells, 1965, 289-290).

Table A6.2: A Comparison of the Derived Classification With Other Forest Type Classifications

BUYS' CLASSIFICATION[2]	CORRESPONDING CLUSTER ANALYSIS GROUPS	FRI WORKING GROUP	CORRESPONDING CLUSTER ANALYSIS GROUPS
Black spruce	5[1] Black spruce 31 Black spruce - Balsam fir 16 Black spruce - Tamarack	10[3] Spruce Dominant	5 Black spruce 31 Black spruce - Balsam fir 16 Black spruce - Tamarack 8 Black spruce - Jack pine + others 59 White spruce - Black spruce White birch 71 White spruce - Balsam fir - Poplar
Black spruce - Jack pine	8 Black spruce - Jack pine - others		
		7 Jack pine Dominant	2 Jack pine Dominant
Jack pine	2 Jack pine Dominant	33 Poplar Dominant	18 Poplar Dominant
Spruce - White birch	59 White spruce - Black spruce White birch 71 White spruce - Balsam fir - Poplar 1 White birch Dominant	36 White birch Dominant	1 White birch Dominant
Poplar - White birch	19 Poplar Dominant	13 Balsam fir	no corresponding group

[1]Group code from cluster analysis.

[2](Buy, 1968,8).

[3]Code used in FRI computer files.

The comparison with the Buys' work also showed a strong correspondence between the two classifications. Buys' subtypes lend support to the subdivision of the Black spruce dominated stands, as he makes a distinction between dry and wet habitats. On the other hand, the Spruce-White birch subtype lumped several combinations of species into one category. It seems that this situation is similar to that for Black spruce in the FRI working groups.

In summary, the classification derived by cluster analysis is also valid from an ecological perspective. There is evidence that it is more sensitive to variations in species composition than the other classifications. This greater sensitivity is advantageous to this study as the classification is more likely to reflect furbearer habitat preferences. One adjustment was made to the groups before the trapline forest stands were classified. Groups 59 and 71 were merged because it was felt that group 71 did not reflect a sufficiently different habitat. In addition, there was only one stand in group 71, which suggested that this stand was a chance variation of those in group 59 (group 59 and 71 are also merged in the cluster analysis; see Figure 3.3.

APPENDIX 7

THE METHOD OF SELECTION OF A SAMPLE OF TRAPPERS AND OF TRANSFERRING TRAPLINE INFORMATION TO FOREST RESOURCE INVENTORY MAPS

The selection of a sample of trappers was based on the following criteria: trapping territories had to be situated in areas which had FRI coverage; trappers had to have trapped the area for at least four years; trappers had to have been surveyed in the Treaty 9 land use study; the sample had to be uniform in experience and effort. Fifteen trappers in the study area met the above criteria. Most trappers were rejected because they were not sampled in the Treaty 9 land use study or did not trap the same area for at least four years. The sample, though small, was geographically representative of the entire study area (see Fig. A7.1).

Collection of the habitat information was accomplished by first overlaying the trapping area and FRI maps. The usual cartographic techniques could not be used because the maps were quite large and at two different scales, 1:69,360 for the FRI and 1:250,000 for the land use maps. Instead, colour slides of the trapping area maps were taken using a 35 mm. copy camera and then projected onto the FRI maps. Use of a copy stand during photography and matching outlines

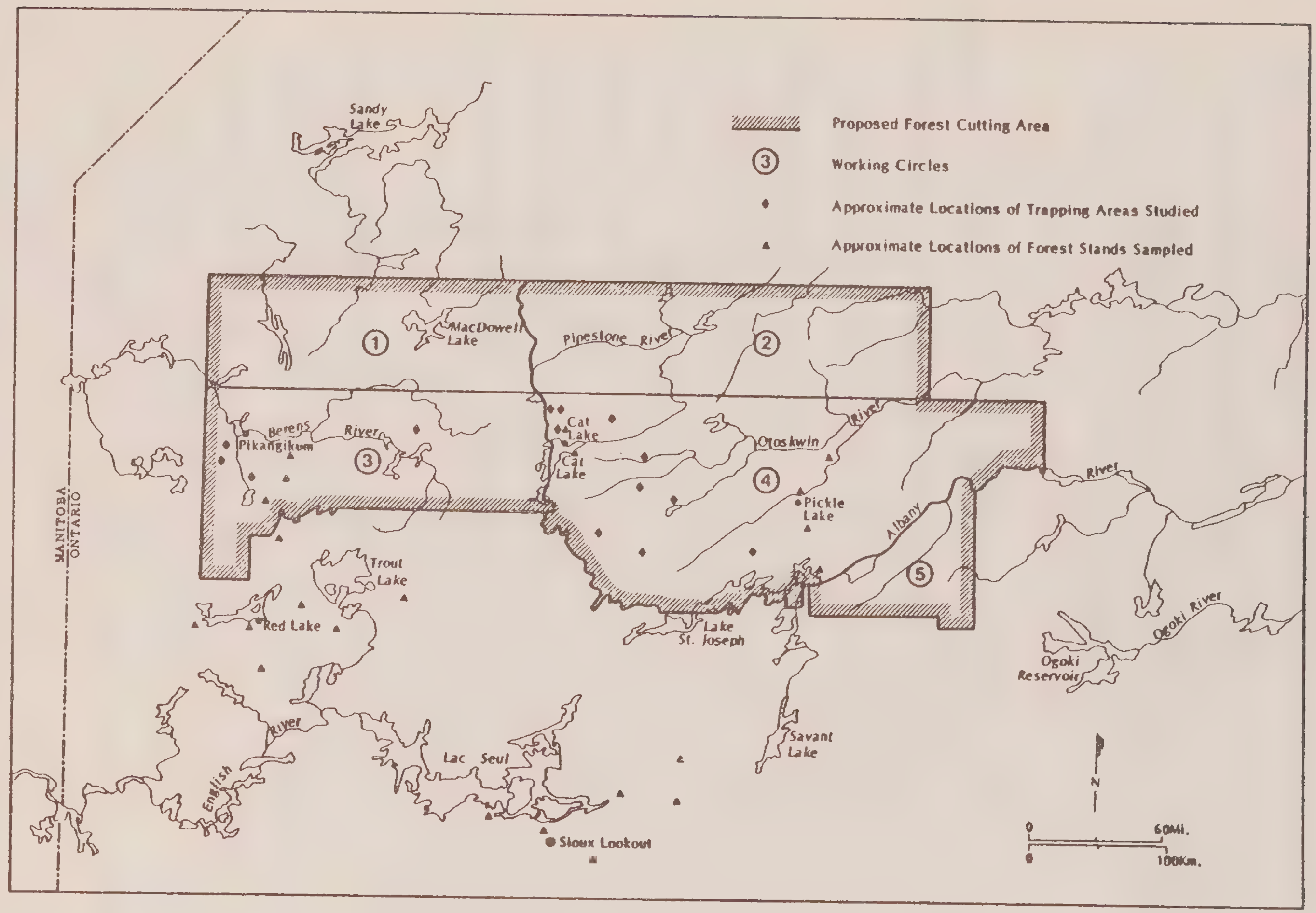

Fig. A7.1 Approximate locations of traplines used in regression analysis and of forest stands sampled to determine successional trends.

of lakes and rivers during projection resulted in very little distortion and an accurate equalization of scales. The trapping area boundaries were then drawn on the FRI maps using a pattern of dots as described on page A3.5.

The next step was the recording of all the identity codes for all the productive forest stands in each area. These codes were needed to retrieve individual forest stand data from computer tape records, which were then used for classification.

Collection of the other habitat data required a different approach because the data do not appear on FRI computer tapes. A transparent overlay of regularly spaced lines was used to obtain index densities of permanent streams of under and over 6.7 metres width, and lakeshore length. The index was the total number of times the transect lines crossed each of the three categories. Estimates of areas of water, treed and open muskeg, brush and alder, and barren and scattered classes were obtained using a random dot sampling technique. A series of random dots were located on each of the lines of the previously described overlay. A record was made of the number of dots that occurred in each of the above classes as well as in productive forest stands as a whole. The acreage for each class in each trapping area was then estimated by multiplying the relative frequency (number of dots for a class ÷ total number of dots in trapping area) of a category by the total trapping area. The accuracy of this method was checked and was proved adequate by comparing the estimated total area of habitat other than productive forest with that obtained from the FRI.

APPENDIX 8

1979

Trapper Survey

Interviewer: Date:

1. IDENTITY OF TRAPPER Mr.
Mrs.
Trapper's Name Miss

Trapper's Age (Approximate if necessary)

Residence

Registered trapline number (if available)

2. WHERE IS TRAPPING DONE? (Osnaburgh House residents need not answer this question. We have the information already)

Outline actual area used on 1:250,000 map, showing routes normally travelled.

Show any major shifts in trapline location during trapper's lifetime, with year(s) of change(s).

Outline reasons for trapline location changes below.

3. CHANGES IN TRAPPING OBSERVED

Has the trapper observed any changes in

a) Types

b) Numbers of animals trapped?

(N.B. We're not worried about regular fluctuations such as in hare and lynx.)

Were there any changes in any of the following, not mentioned above (Beaver, Lynx, Fisher, Otter, Muskrat, Mink, Squirrel, Hare)

Which changes were most important from the trapper's point of view?

Can the trapper suggest reasons for these changes?

Has the trapping time spent by the trapper changed over the years?
(Tick (✓) each box when much trapping done.)

	PreChristmas	Christmas - March 1st	after March 1st
1941-5			
1946-50			
1951-5			
1956-60			
1961-5			
1966-70			
1971-5			
1976 on			

Can the trapper give reasons for any changes in the question above?

4. FOOD AND TRAPPING

What parts (if any) of the following animals are use for food?

	Part(s) used	How often eaten? Eaten whenever caught	Usually eaten (more than 1/2 the animals)	Rarely eaten
Beaver				
Lynx				
Martin				
Fisher				
Otter				
Muskrat				
Mink				
Squirrel				
Hare				

Does the trapper hunt while trapping?

( ) Always

( ) Usually (more than half the time)

( ) Rarely

( ) Never

What proportion of meat (weight) eaten by the trapper and his family throughout the year is hunted and/or trapped while trapping?

( ) None

( ) Less than 25%

( ) 25 - 50%

( ) More than 50%

Does the trapper fish while trapping?

( ) Always

( ) Usually

( ) Rarely

( ) Never

What proportion of fish eaten throughout the year are taken while trapping?

( ) None

( ) Less than 25%

( ) 25 - 50%

( ) More than 50%

If the trapper stopped trapping how would this affect the amount of hunting or fishing done? (What we need to know is if the trapper would make more special hunting trips)

How many people does the trapper support?

( ) Adults # ( ) Children under 12

Does anybody else in this group trap or hunt? (Details, including names)

5. TRAPPING AND SOCIAL LIFE

What effect have changes (if any) in trapping season or effort had on:

Time spent with the family

Time spent on the reserve or in bush

Time spent in town

How does the trapper feel about the above?

6. ECONOMICS OF TRAPPING

Has the trapper's income from trapping risen or fallen? (How and why?)
Include $ figures if the trapper is happy to give them.

How have changes (if any) in trapping affected the trapper's other income?
(Fishing, wage-labour, wildricing, handicrafts sold, welfare)

Have changes in trapping affected amount of goods purchased as opposed to made? (e.g. fuel, clothing, food)

How many furs (approx.) and what types are used in handicrafts for sale by trapper, family, or friends?

How many furs (approx.) and what types are retained for personal use?

FEELINGS TOWARDS TRAPPING

What does the trapper like or dislike about trapping as a way of life?

On balance how does the trapper feel about trapping?

If the trapper had the choice of the following winter occupations, which would he/she choose, and why? Put a number beside each, where 1 is liked
2 is neutral
3 is disliked

( ) Trapping
( ) Logging operation (live in camp)
( ) Logging operation (live at home)
( ) Work in pulp mill
( ) Work in mine
( ) Other wage labour
( ) Welfare

Any comments on the above?

Does sending children to school have any effect on amount of trapping done by parents or by youngsters? (The trapper may draw a distinction between day school and boarding school and <u>if</u> he does it should be noted)

8. <u>QUESTIONS ABOUT LOGGING</u> (to be asked last)

(If the answers don't give much information ask whether effects are good or bad)

Does logging affect the trapper through employment, through effects on the trapline, or by any other means?

How do logging roads affect the trapper through employment, the trapline, or any other means?

Do forest fires affect the trapper through employment, the trapline, or by any other means?

When was the first logging on the trapper's trapline?

What proportion of the trapline has now been logged?

( ) None, or virtually none (less than 1/10 of forested area)

( ) Between 1/10 and 1/4 of forested area

( ) 1/4 - 1/2 of the forested area

( ) More than 1/2 of the forested area

How does the trapper feel about his area being logged?

Does the trapper know of any former trappers who gave up trapping because their areas were logged over? (Names?)

Has any government official ever consulted the trapper, the chief or the elders about the effects of logging on trappers?

If the trapper has any other ideas, statements, feelings about logging, etc., please make notes.

9. <u>QUESTIONS ABOUT FURBEARERS</u> (swamp, bog, marsh, etc.)

What kinds of land are important for the following animals (Tick each box that is important)

					MOST COMMON TREES										
	Marshes	Bogs	Black Spruce Swamps	Alder	Tamarack Black Spruce & Alder Swamps	Poplar & others	Birch & others	Jack Pine & others	Upland Black Spruce & others	Balsam Fir & others	White Spruce & others	Recently* burnt areas (upland)	Recently burnt areas (swamps)	Recently logged areas (upland)	Recently logged areas (swamps)
Beaver															
Martin															
Lynx															
Mink															
Otter															
Fisher															
Squirrel															
Hare															

Add comments if necessary

* Within 10 years

APPENDIX 9

PROCEDURE FOR WEIGHTING THE IMPORTANCE OF EACH HABITAT TO FURBEARERS IN AN UNLOGGED LANDSCAPE

1. Nineteen trappers were polled to determine which habitats are important to which furbearers (see appendix 8). The importance of each habitat for each species was determined as follows:

$$I_x = \frac{N_{I,x}}{N_{I',x} \Big|_{I=max}^{I=1}}$$

where,

I_x = importance of habitat I to species x

$N_{I,x}$ = the number of times habitat I was cited by trappers as important for species x

max= the total number of habitats

In an adjusted set of habitat importance values for unlogged landscapes, the importance values of upland and lowland logged areas were not included in the calculations.

2. Government furbearer returns were examined for sample unlogged areas and the economic importance of each species was determined relative to the total harvest:

$$E_x \quad \frac{C_x \cdot P_x}{\sum \left[C_x \cdot P_x \right]_{x=tot}^{x=1}}$$

where,

E_x = proportion of furbearer catch value attributable to species x

C_x = the number of pelts of species x sold

P_x = the average pelt price for species x

tot = the number of furbearer species

3. The economic value of each species was partitioned according to habitat importance:

$$E_{x,I} = I_x \cdot E_x$$

where,

$E_{x,I}$ = the economic importance score of habitat I for species x

4. The habitat values were summed to give a measure of the economic importance of each habitat:

$$E_I = \sum_{x=1}^{x=tot} E_{x,I}$$

where,

E_I = the economic importance score for habitat I

The sum of these values for all habitats will be unity.

APPENDIX 10

DEVELOPMENT OF A LANDSCAPE MODEL

Objective

The objective of the model is to use the principles outlined above to estimate the amounts of different types of ecosystems in the Northwest Ontario landscape, through time, assuming various management policies. From the estimates, predictions may be made of the effects of landscape changes on trapline yields, using the information gathered in the previous chapter.

The Basic Form of the Model

The model devised for this study consists of a matrix of 'cells' each representing the area of a given forest type of a given age (e.g., the area of forest type 02 of 40-60 years of age). The model runs through simulated time which is divided into 20 year periods. At the end of each time period, any part of the area tabulated within a cell may undergo one of three fates (Fig. A10.1).

1) It may be disturbed and return to a pioneer cell (a cell containing forests of the youngest age group). The type of forest regenerated will depend on the nature of the disturbance, and the type and age of the previous forest.

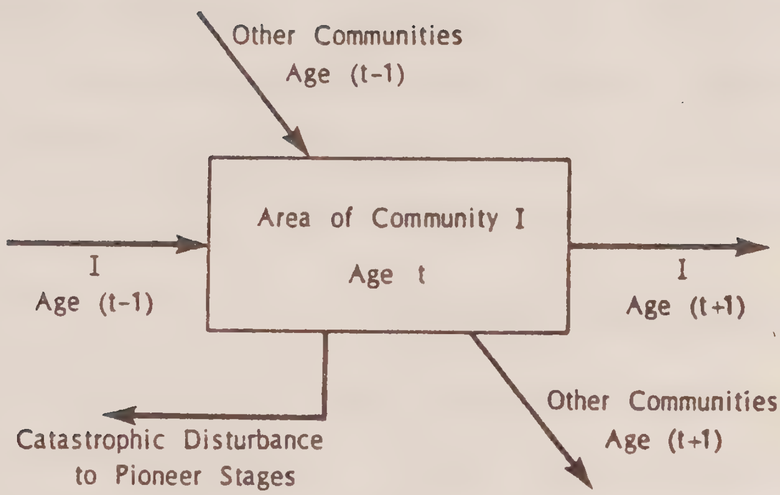

Fig. A10.1 The basic principle of the landscape model. The figure shows one cell in a matrix of vegetation communities (I) which are divided into various age groups(t).

2) It may transfer to another forest group of the next oldest age, either through successional change or because of some minor disturbance such as ground fire.

3) It may transfer to the next oldest age group of the same forest type.

Thus the model tabulates at any particular time the area of communities of each age and of each type. The rates at which disturbance and successional change occur are specified in the input data to the model. These variables have been determined as described below, as is the procedure for simulating logging. Details of the computer program are given in appendix 11.

Successional Trends

The present age distributions of the forest type groups are shown in Figure A10.2. These distributions suggest that types 01 (birch), 02 (jackpine), and 18 (aspen) may be pioneer forest communities, but do not rule out the possibility that other types also fill this role. Field observations, literature (Fowells, 1965) and conversations with local foresters (M. McIntyre, D. Portier, pers. comm.) confirm that any of the nine forest types except balsam fir (31) and white spruce mixtures (71) may function as pioneer communities.

To define the successional trends more precisely, observations were made on 139 forest stands in and around the study area (Fig. A7.1). The canopy type and the regeneration were recorded for each stand, thus demonstrating any incipient successional changes (Figure A10.3).

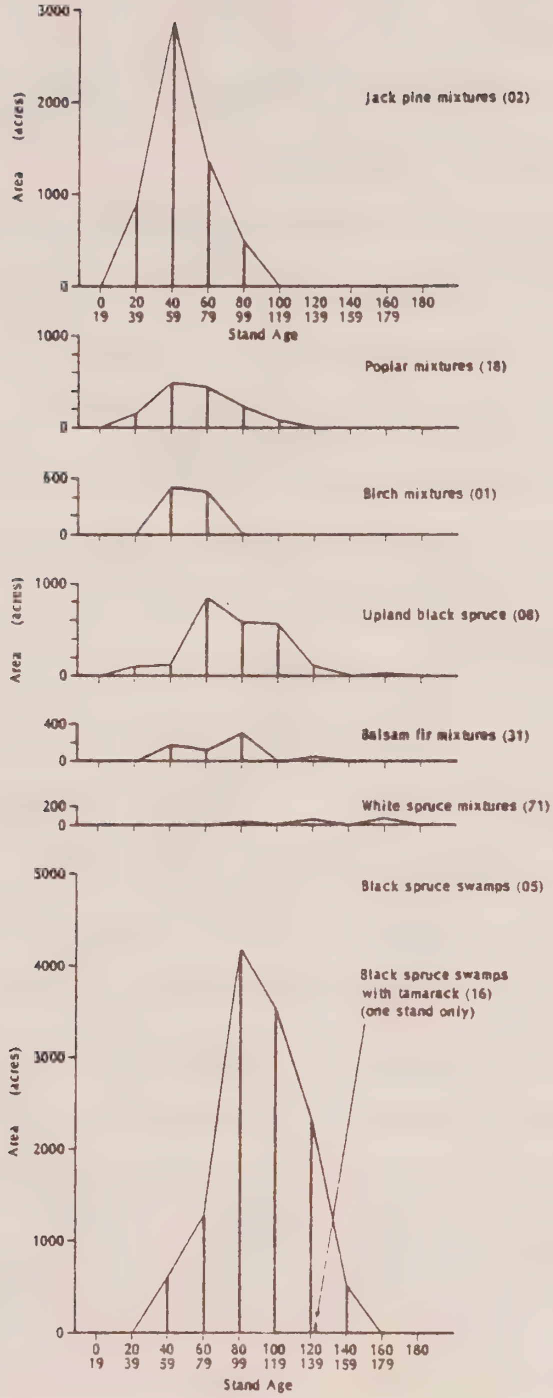

Fig. A10.2 Age distributions of the forest types identified in the cluster analysis (Fig. 3.3). There are 279 stands in the sample.

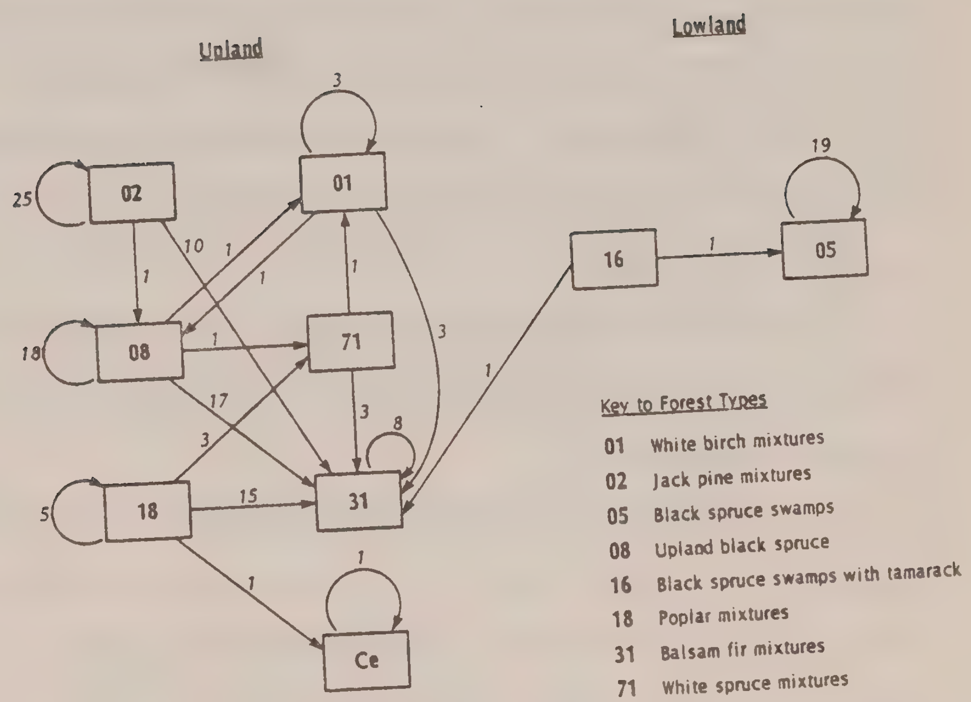

Fig. A10.3 Successional trends in the study area as determined by field observations. Trends between forest types are indicated by arrows and the number of stands undergoing each trend is shown by numbers in italics. The data cannot be interpreted in a strictly quantitative fashion because the sample was not chosen randomly.

The trends shown cannot be interpreted in a strictly quantitative fashion since the sample of stands could not be chosen randomly (rare forest types were deliberately sought out to provide maximal qualitative information.)

Quantification of successional trends is only possible if the model proposed above can be 'forced' using simultaneous equations. This requires that other variables, such as rates of disturbance of particular forest groups of particular ages ('age-specific disturbance rates') be known. Unfortunately, the time available for the study (August 1979-March 1980) did not allow the authors to collect this information. The model has therefore been simplified in practice to two functional separate components: the upland forest and the lowland forest.

In spite of the difficulty noted above, it is possible to draw some general conclusions about succession in the forest landscape of Northwestern Ontario.

In the upland areas the main pioneer communities are those dominated by jack pine (Group 02), by black spruce in mixtures with other species (Group 08) and by aspen in mixtures (Group 18). In each of these cases pioneer species are gradually supplanted by balsam fir (Group 31) which is shade tolerant. The transition tends to occur especially when older pioneer trees begin to blow down, thus releasing the fir from competition. The white spruce stands (Group 71) also tend to arise through selective destruction of black spruce and aspen, thus allowing growth of this shade-tolerant species, but even in these cases balsam fir tends to predominate eventually.

The birch community (Group 01) may be a pioneer type, or may arise through the break-up of old black spruce (08) and white spruce stands (71). Most birch stands are eventually overtaken by balsam fir. The white cedar stands have not been considered here since they only occur on the southern margin of the study area.

In the lowland areas, there is much less variation in forest stands, though there is considerable diversity in open and shrubby communities. The pioneer tree species here is black spruce growing in almost pure stands (Group 05), but supplemented in relatively mineral-rich areas by tamarack (Group 16). It is probable that many of the areas classified as 'open muskeg' in the FRI data eventually undergo a transition to 'treed muskeg' and thence eventually to spruce stands (Group 05). Indeed, the peculiar age distribution of lowland stands (Figure 4.3) is made much more explicable by adding the open and treed muskeg areas to the younger age classes. We have not been able to confirm the extent of this trend during this short study.

Regeneration Following Disturbance

Disturbance has been divided into two kinds, the catastrophic type in which virtually all above-ground components of the ecosystem are destroyed, and sub-catastrophic disturbance in which only selected components are removed. The former is characterized by crown fire or by clear cutting, whereas the latter is represented by ground fires or insect attack on a mixed (i.e., not monospecific) forest. In practice, there is a gradation between these two types of disturbance, but the distinction is conceptually useful and also

facilitates construction of the computer model.

On the basis of our own field observations, conversations with local foresters (M. McIntyre, D. Portier, pers. comm.) and reference to the literature (Woods and Day, 1977) we believe that most sub-catastrophic disturbance other than ground fires render ecosystems more prone to subsequent crown fires, and these usually occur within about two decades of the initial disturbance. Insect attack and windthrow thus serve as a prelude to catastrophic disturbance and are ignored in the model. Ground fires alter the forest however, but render it less prone to subsequent crown fires because fuel sources are consumed. Thus ground fires may be regarded (in a loose sense) as an agent for "successional" change.

Whether or not a particular species is likely to arise after various forms of disturbance has been estimated by reference to the literature (Fowells, 1965), by field observations, and through consultation with local foresters (M. McIntyre, D. Portier, pers. comm.). These trends are summarized in Table A10.1. By reference to the species composition of particular forest type groups it is thus possible to predict the type of regeneration expected following various disturbances (Table 4.2), and this was again confirmed by field observations and consultation with a local forester (M. McIntyre, pers. comm.).

Fire Rates Used in the Model

The present age distribution of the ecosystems in the study area is a product of the original rates of disturbance, and of recent changes brought about by fire control. One needs to know original

Table A10.1 Reproduction Characteristics of Tree Species Found in the Study Area[1]

Tree Species	Normal Regeneration Conditions	Vegetative Reproduction	Age of First Flowering	Seed Viability	Maximum Seed Distribution	Conditions for Germination	Seeds Usually Withstand Fire	Other Comments
White Birch	[2]Needs light	Stump Sprouts	15 years	Lost after a few months	Usually close to parent tree but can travel far	Mineral soil	No	
Aspen Poplar and Balsam Poplar	After logging and light burning	Sprouts from roots in light and/or heat	20 years	High but only for a few days or weeks	Several miles?	Moist mineral soil	No	
White Spruce	Usually reproduced in maturing forest	None	30 years (optimum 60 years)	At least one season	330 feet[3]	Moisture needed not on deep litter, moss, etc. Usually on decayed wood	No	Seedlings often damaged if there is cover for hares
Black Spruce	After fire, but also in deep shade. Can invade sedge mats in bogs	Layering common in swamps. Also from adventitious root buds	10 years? Very little at first	More than 15 years	94% within 100 feet. 300 feet maximum	Mineral soil (uplands). Sphagnum moss (lowlands). Not on feather moss	Sometimes	
Balsam Fir	In undisturbed forest, also after logging	Layering (not important)	15 years (good seeding after 30 years)	Low (little information)	500 feet. Effective distance is much less	Will not compete with herbs or germinate in deciduous litter	No	Can be suppressed many years. Responds to removal of overstorey
Jack Pine	After fire or logging	None	5-10 years (open grown) 15-25 years (in stands)	Usually several years	Three tree lengths	Mineral soil	Usually	

1. Information drawn from field observations and from Fowells (1965).
2. All notes above are generalizations and must be interpreted as such.
3. May be an underestimate.

rates of disturbance (largely through fire), before fire control was initiated. Only then can one initiate a scenario in the model which does not incorporate fire control. The method for doing this has been to set up a hypothetical age distribution for sixty years ago and then, assuming certain rates of disturbance, to run the distribution through time to the present. A comparison can thus be made of the observed present age distribution and the prediction developed. By iteration one can develop a scenario giving the closest match between observed and predicted present values. By inference, the disturbance rates used in the 'best' simulation are those which probably occurred in nature. The details of this method are given in appendix 12.

The results of the iterations are shown in Figures A10.4 and A10.5 The process not only indicates the effectiveness of present fire control, but also gives a starting age distribution for the computer model for the year 1917. Both these pieces of information have been used in the modelling exercise.

The Logging Component of the Model

A logging rotation is the number of years required to establish and grow timber crops to a specified condition of maturity. Thus, in this study area a 70 to 80 year rotation is considered appropriate for most upland stands, and a 100 to 120 year rotation for lowland areas (M. McIntyre, pers. comm.). If, in the case of the upland areas, one eightieth of the area is logged each year, this represents the maximum cutting which could theoretically be envisaged on a sustained yield basis. It does not allow, however, for any timber losses due

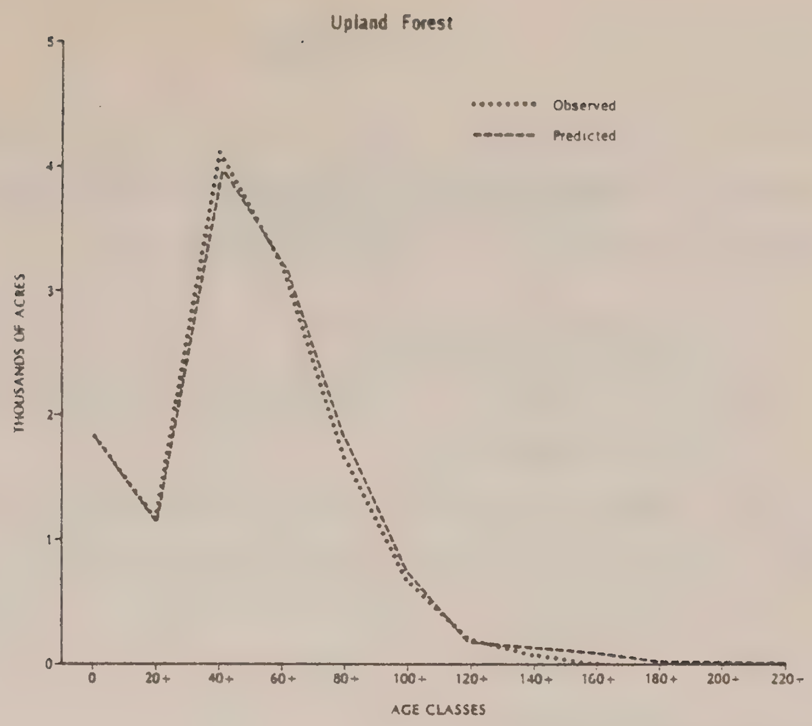

Fig. A10.4 Comparison between the present observed upland age distribution and the best prediction developed through simulation of past disturbance. See page A10.8 for explanation.

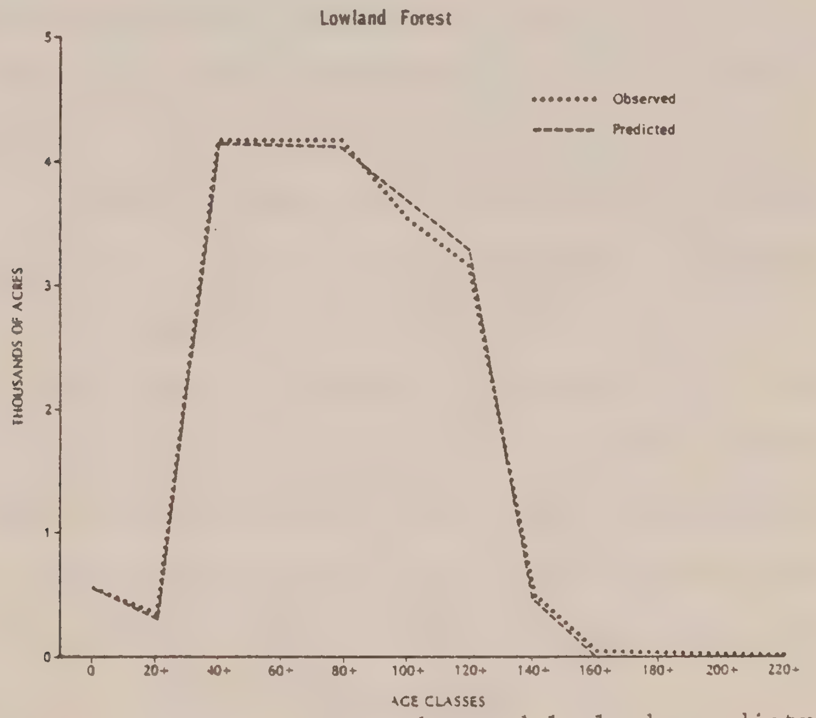

Fig. A10.5 Comparison between present observed lowland age distribution and the best prediction developed through simulation of past disturbance. See page A10.8 for explanation.

to fire, spruce budworm attack, blowdown or any other disturbance. In both the upland and lowland components of the model we have therefore assumed three scenarios, as follows:

1) No logging or fire control.
2) Fire control at the present level of effectiveness but no logging.
3) Logging at 100 per cent of the maximum theoretical rate based on 80 year upland and 120 year lowland rotations.

Testing the Model

The completed model should ideally be tested in some objective fashion, using independently based data for comparison with the model output. Unfortunately we have very little data with which to work, but there is one set of information which can be used. A series of fire maps recently prepared by the Federal and Ontario governments (Donnelly and Harringon, 1978) allows computation of fire disturbance rates in the study area for the last three 20-year periods. It is thus possible to verify the rates of burning used in the model. Table A10.2 shows that in the last two 20-year periods there is close agreement between the simulated and observed burning rates. In the preceding period (1917-1936), however, there is a marked discrepancy: the rates of burning indicated by the model are much higner than those suggested by the fire maps. There are two reasons to suspect that in this case the model is more accurate than the fire maps: one is that the area of forest currently present which must have arisen from fires in this period is even now greater than is suggested

Table A10.2: Historical Forest Fire Trends in the Proposed Reed Timber Licence Area

Per cent Disturbance of Land Area

		Simulation		
Year	Fire Map[1]	Total	Upland	Lowland
1921-1935	9.0	24.8	33.6	20.1
1936-1955	4.3	4.5	9.0	1.8
1956-1975	7.3	7.1	14.1	2.8

[1]Donelly and Harrington, 1978.

by the fire maps. (We have checked the stand dating methods used in FRI data gathering and find them to be accurate, using independent field observations). The other reason is that some of the areas burnt in the 1917-1936 period have since been reburnt and thus could not have been detected in air photos used by those compiling the fire maps. The fire maps thus underestimate rates of fire in older time periods.

On the basis of the above we are confident in the fire trends used in the model. Other aspects of the model cannot be tested at this time and the logging rates are presented as a possible scenario since we cannot presently predict economic or political trends with any accuracy beyond the span of a few months.

APPENDIX 11

LANDSCAPE FOREST SIMULATION PROGRAM: 'FORESTSIM'

1. General Description

The forest simulation program is designed to enable the user to study the effects of various management practices on the nature of forested landscapes. The principal factors in forest development which are modelled include 'birth' of ecosystems following catastrophic disturbance, successional change and changes caused by minor disturbances, 'death' of ecosystems by catastrophic disturbance, fire control and logging. Each area of recently disturbed land undergoes succession, and later catastrophic disturbance giving rise to a mosaic of forest stands of various age and composition. The model user must define the rates of succession and disturbance which apply to a particular forest type and age group, and in addition, the level of fire control and logging which is to apply during a specific time period. The nature of the forest in the future will depend on the values of these parameters.

To use the program, one must:

(1) recognize one or more forest types within an area on the basis of species composition;

(2) determine the age of individual stands in the area (with respect to the time since the last catastrophic disturbance), and group these into age classes of some convenient duration;

(3) define the rate and type of successional change in terms of the forest groups recognized (i.e., which groups tend to become which other groups, and how rapidly does this happen?);

(4) determine the rate of natural disturbance affecting each age class of each forest type, and be able to indicate the nature of regeneration following disturbance.

This information must be expressed in the form of fractional transfer coefficients between age classes of different forest types, to simulate the changes in composition which occur over an area with time.

The program presents several options which may be selected when the user is prompted by the program. The model will simulate:

(1) 'natural' forest growth;

(2) forest growth in the presence of fire control;

(3) forest growth in the presence of logging activities.

If the user has set up appropriate data sets with the required information, any combination of the preceding options may be executed for any number of time periods. The length of each period must correspond to the length of the age classes defined. There is no inherent restriction on the number of age classes or forest groups that may be defined; however, the central processor unit (CPU) storage required will increase dramatically with the number of forest groups and age classes used.

2. Simulation Input

Before executing the program, the user must create all data sets required for the specific simulation. The sub-function ENTERDATA is designed to facilitate the entry of any data set not already available to the user. This function may be executed by responding 'YES' when asked if data sets need to be entered. The following sections discuss the important logical considerations when defining each data set.

3. Original Forest Composition

To execute the forest simulation program, one must first have defined the forest types or groups which comprise the study area, as well as their age classes. The number of years comprising each age class will depend on the accuracy with which the ages of the various forest stands can be determined in the field. It is necessary to define the same number of age classes for all forest types, even though in reality certain forest types may never exist as a pioneer forest, and others may never exist as a mature forest. This is necessary only to facilitate the calculations. It presents no problems in the outcome, since the area occupied in any seemingly unrealistic case will always be zero.

4. Successional and Disturbance Transfer Coefficients

Successional and disturbance transfer coefficients must be calculated for all possible transfers between forest groups.

These coefficients represent the fraction of forest types of a given age, undergoing a given transfer. In cases where no transfer occurs, the value of the coefficient will be zero. Coefficients representing successional transfers from one group to itself must be assigned the value zero. These transfers are handled automatically by the program.

The sum of successional and disturbance transfer coefficients from a given age class of a given forest group to all other groups must logically not exceed 1.0, since one cannot transfer more area than is available. When the sum of these coefficients for a given age class is less than 1.0, the residual area is transferred automatically to the next oldest age class within the same forest group.

The sum of disturbance transfer coefficients in the oldest age class of a given forest group must logically be equal to 1.0, since by definition, stands belonging to the maximum age class must be destroyed before entering the next age class. Similarly, successional transfer coefficients from the oldest age class of a given group must equal zero.

5. Fire Control Coefficients

Fire control coefficients act to alter the amount of natural disturbance which would occur in the absence of fire control. Fire control reduces the natural disturbance transfer coefficients to some fraction of their previous level. If fire control effectiveness deteriorates the fire control coefficients may exceed unity. A fire

control coefficient of 0.5 would reduce the disturbance rate to half the previous rate; a coefficient of 1.5 would increase disturbance by half.

Fire control coefficients must be calculated for all possible disturbance transfers. If the disturbance transfer coefficient is already zero, then of course it will not matter what the value of the fire control coefficient is, since there will be no disturbance in any case. Also, in order to maintain total disturbance in the oldest age class in the simulation, these fire control coefficients must be equal to one; otherwise, something less than total disturbance could result in the maximum age class.

7. Logging Procedure

To mimic logging of the study area during a simulation period, the user must:

(1) specify the age classes of each forest type which may be logged;

(2) indicate by way of logging regeneration transfer coefficients, which pioneer forest groups are likely to develop following logging of a particular forest type;

(3) indicate the demand for timber during a given simulation period.

The logging matrix is composed of integers showing whether, for forest type of a particular age class, logging is permitted (1) or is not permitted (0).

If, during a particular time period, the demand for timber exceeds the supply of area capable of being harvested, all available stands of timber will be logged. Otherwise, if the demand is less than the supply, the amount harvested from each forest group will be proportional to the area occupied by loggable stands of that forest group, relative to the total area capable of being harvested. To satisfy the amount to be harvested from each forest group, the program begins at the oldest loggable age class and works towards the younger loggable age classes, until the required acreage has been harvested for a given group.

Similar in principle to the disturbance transfer coefficients, the logging regeneration transfer coefficients indicate the nature of an area after it is logged. All possible transfers must be indicated by assigning a coefficient between 0 and 1.0. The sum of regeneration transfer coefficients from a given age class of a given group, to all other groups, must logically be equal to 1.0, since the total area logged in each age class must be transferred.

7. Changing Input Information

The user may specify changes in input data used throughout the simulation. For example, one may wish to run the simulation without fire control or logging for a number of periods, and then introduce fire control and logging for the remainder of the run. These options may be implemented and changed as many times as the user desires, keeping in mind that when more changes are required, more CPU storage

is necessary to run the program.

When prompted to enter simulation set 1, 2, 3, etc. the user must respond by providing the appropriate parameters (disturbance and succession coefficients, etc.) to be used during that period. Each set of parameters may be run any number of times before introducing a new set. This allows for considerable flexibility in testing various management strategies.

8. Simulation Output

There are several options for presentation of output. Generally, the user will be interested in obtaining tables of input information as well as a detailed print-out of the results. Under certain circumstances, however, a lengthy output may not be required. The user may elect to forego the print-out of input information and/or select only specific periods for which the results are to be presented.

9. List of Error Messages Built Into the Program

9.1 Dimension Errors

1. DISTURBANCE MATRIX HAS IMPROPER DIMENSIONS

This matrix must be of dimensions # forest groups x # forest groups x # age classes such that disturbance rates for a given age group of a given forest group, to all other forest groups including itself are represented in the matrix. The user may be assisted in setting up an appropriate data set by typing 'ANYNAME ENTERDIST' where 'ANYNAME' is the variable name one wishes to use for the disturbance matrix.

2. SUCCESSION MATRIX HAS IMPROPER DIMENSIONS

As in ERROR #1, dimensions must be # forest groups x # forest groups x # age classes. By typing 'ANYNAME ENTERSUC', the user will be assisted in entering the successional transfer matrix.

3. FIRE CONTROL MATRIX HAS IMPROPER DIMENSIONS

Dimensions must be # forest groups x # forest groups x # age class as above. Type 'ANYNAME ENTERFIRE' for assistance.

4. LOGGING MATRIX HAS IMPROPER DIMENSIONS

So that all age classes of each forest group are represented dimensions must be # forest groups x # age classes.

5. LOGGING REGENERATION MATRIX HAS IMPROPER DIMENSIONS

Transfers from each age class of a given forest group to all other forest groups, including itself, must be represented. Therefore the required dimensions must be # forest groups x # forest groups x # age classes.

9.2 Logic Errors

1. THE SUM OF SUCCESSION MATRIX + DISTURBANCE MATRIX MUST NOT EXCEED 1.0

Since these coefficients represent a fractional loss from the available acreage in a given age class of a given forest group, such a loss must logically not exceed the available supply.

2. THE SUM OF DISTURBANCE COEFFICIENTS IN THE OLDEST AGE CLASS FOR EACH FOREST TYPE MUST = 1

The maximum age any stand may reach is predetermined by the number of age classes specified. Since the transfer of acreage out of the oldest age class for each forest group must be complete, these coefficients must = 1.0.

3. THE LOGGING MATRIX MUST ONLY CONTAIN THE INTEGERS 1 AND 0

The purpose of this matrix is simply to indicate whether a stand of a type and age is loggable or not. Such a binary choice requires only the integers 1 or 0, indicating that the stand is loggable or not loggable, respectively.

4. THE SUM OF LOGGING REGENERATION TRANSFERS FOR THE HARVEST OF A GIVEN AGE CLASS OF A GIVEN FOREST TYPE MUST BE 1

This is necessary so that all of the harvested acreage is allocated to some pioneer group, whether it be the same or some different forest group.

5. FIRE CONTROL MUST NOT CHANGE THE DISTURBANCE RATE OF THE OLDEST AGE CLASS OF ANY FOREST GROUP

The fire control coefficients in the oldest age class must therefore be 1 so as to retain total disturbance of these stand of maximum age.

6. THE SUM OF SIMULATION PERIODS FOR EACH SET OF PARAMETERS MUST EQUAL THE TOTAL NUMBER OF SIMULATION PERIODS REQUESTED.

LANDSCAPE SIMULATION PROGRAM LISTING

```
     ∇ FORESTSIM;SUCMAT;DISTMAT;FIRE;FIREMAT;LOGIT;LOGMAT;DEMAND;CURRENTDEMAND;N;LOGREGENMAT;G;A;CURRENT;HARVEST;NEW;SU
       PPLY;LOGCOMP;OUTERROR;LOGICERROR;SETNUM;DEMANDSTORE;SETPERIODSTRACE;CURRENTSUPPLY;CONTINUE
[1]   ⍝THIS FUNCTION DIRECTS THE EXECUTION OF THE ENTIRE FOREST SIMULATION
[2]   ⍝BY CALLING UPON SUB-FUNCTIONS TO PERFORM VARIOUS PROCEDURES.  ALL
[3]   ⍝VARIABLES USED IN THE SIMULATION, WITH THE EXCEPTION OF THOSE
[4]   ⍝LOCALIZED WITHIN SPECIFIC SUB-FUNCTIONS FOR THE PURPOSE OF INTERNAL
[5]   ⍝COMPUTATIONS, APPEAR IN THE HEADER LINE.
[6]    CONTINUE←'Y'
[7]   ⍝REQUEST INPUT INFORMATION
[8]    SIMQUEST
[9]    →('N'∊CONTINUE)/0
[10]  ⍝INITIALIZE MATRIX VARIABLES OF APPROPRIATE DIMENSIONS
[11]   NULLPARAMETERS
[12]  ⍝DIRECT ASSIGNMENTS OF VARIOUS PARAMETERS TO BE USED
[13]   ENTERSETS
[14]  ⍝STOP EXECUTION OF PROGRAM IF INPUT INFORMATION IS INCONSISTENT
[15]   →(OUTERROR=1)/0
[16]   →(LOGICERROR=1)/0
[17]  ⍝BEGIN SIMULATION
[18]   N←0
[19]  ⍝STORE INITIAL FOREST COMPOSITION
[20]   STAND←(G,1,A)⍴TREES
[21]  ⍝INITIALIZE LOGGING PARAMETERS
[22]   LOGCOMP←(G,1,A)⍴0
[23]   CURRENTDEMAND← 1 1 ⍴0
[24]   CURRENTSUPPLY← 1 1 ⍴+/+/[2] LOGMATSTORE[1;;]×TREES
[25]   SETNUM←0
[26]  ⍝INITIALIZE CURRENT SIMULATION PARAMETERS
[27]  GETASET:
[28]   NEWSET
[29]  ⍝RUN SIMULATION UNDER CURRENT CONDITIONS FOR SPECIFIED PERIOD
[30]  GENERATE:N←N+1
[31]  ⍝OBTAIN CURRENT FOREST COMPOSITION
[32]   CURRENT←STAND[;(⍴STAND)[2];]
[33]  ⍝APPLY SUCCESSIONAL AND DISTURBANCE TRANSFER COEFICIENTS
[34]   FORNATURAL
[35]  ⍝APPLY LOGGING COEFICIENTS
[36]   FORLOG
[37]  ⍝UPDATE FOREST COMPOSITION
[38]   STAND←STAND,[2] NEW
[39]  ⍝CONTINUE TO APPLY CURRENT PARAMETERS FOR SPECIFIED PERIOD
[40]   →(N<SETPERIODSTRACE[SETNUM])/GENERATE
```

```
[41] ⍝INITIALIZE NEW SIMULATION PARAMETERS IF CHANGE REQUESTED
[42]  →(N<Y)/GETASET
[43] ⍝CALCULATE TOTAL ACREAGE OCCUPIED BY EACH FOREST TYPE
[44]  STAND←STAND,[3]+/[3] STAND
[45] ⍝CALCULATE PERCENTAGE OF ENTIRE AREA OCCUPIED BY EACH FOREST TYPE
[46]  PERCOMPOSITION
[47] ⍝CALCULATE AGE DISTRIBUTION OF FOREST AREA FOR EACH SIMULATION PERIOD
[48]  AGEDIST←+/[1] STAND
[49] ⍝EXPRESS AGE DISTRIBUTION AS PERCENTAGE OF ENTIRE AREA
[50]  PERCENTAGEDIST←100×AGEDIST÷(⍴AGEDIST)⍴ 1 ¯1 ↑AGEDIST
[51] ⍝CALCULATE PERCENTAGE CONTRIBUTION OF EACH FOREST TYPE
[52] ⍝TO TOTAL HARVEST
[53]  UPDATELOG
[54] ⍝PRINT RESULTS OF SIMULATION
[55] PRINT:FORMATSIM
[56]  '1' FMT 10 1 ⍴0
[57]  'IF YOU REQUIRE THE USE OF VARIABLES INITIALIZED DURING THIS'
[58]  'SESSION, REMEMBER TO )SAVE BEFORE SIGNING OFF'
      ∇
      .

      ∇SIMQUEST[⎕]∇
      ∇ SIMQUEST
[1]  ⍝THIS FUNCTION REQUESTS INFORMATION NEEDED TO RUN THE SIMULATION.
[2]  ⍝THE USER MUST FIRST ENTER THE NECESSARY DATA IF HE/SHE HAS NOT DONE
[3]  ⍝SO PREVIOUSLY, AND THEN PROCEED TO SPECIFY DESIRED OPTIONS FOR
[4]  ⍝HIS/HER PARTICULAR NEEDS.
[5]   'DO YOU NEED TO ENTER INPUT DATA BEFORE YOU BEGIN THE SIMULATION?   (Y OR N)'
[6]   →('N'∊⍞)/SIMULATE
[7]   ENTERDATA
[8]   'DO YOU WISH TO CONTINUE WITH THE SIMULATION?   (Y OR N)'
[9]   CONTINUE←⍞
[10]  →('N'∊CONTINUE)/0
[11] SIMULATE:'HOW MANY PERIODS DO YOU WISH TO SIMULATE?'
[12]  Y←⎕
[13]  'WHICH ORIGINAL FOREST AGE DISTRIBUTION DO YOU WISH TO USE?'
[14]  TREES←⎕
[15] ⍝NUMBER OF DIFFERENT FOREST GROUPS
[16]  G←(⍴TREES)[1]
[17] ⍝NUMBER OF AGE CLASSES COMPRISING EACH FOREST GROUP
[18]  A←(⍴TREES)[2]
[19]  'HOW MANY DIFFERENT SETS OF INPUT INFORMATION ARE REQUIRED DURING THE SIMULATION PERIOD?'
[20]  SETS←⎕
```

```
[21]  'ENTER, IN ORDER OF EXECUTION, THE NUMBER OF PERIODS TO BE RUN UNDER EACH SET OF INPUT PARAMETERS'
[22]  SETPERIODS←⎕
[23]  →((ρρSETPERIODS)=0)/RESIZE
[24] INITIALIZE:
[25]  →((+/SETPERIODS)≠Y)/PERIODERROR
[26]  SETPERIODSTRACE←+\SETPERIODS
[27]  →0
[28] PERIODERROR:'***ERROR11***THE SUM OF SIMULATION PERIODS FOR EACH SET OF PARAMETERS MUST EQUAL THE TOTAL'
[29]  'NUMBER OF SIMULATION PERIODS REQUESTED'
[30]  CONTINUE←'N'
[31]  →0
[32] RESIZE:SETPERIODS←1ρSETPERIODS
[33]  →INITIALIZE
      ∇


      ∇ENTERDATA[⎕]∇
      ∇ ENTERDATA;A;T;G
[1]   ⍝THIS FUNCTION ENABLES THE USER TO DEFINE VARIABLES AS INPUT TO THE
[2]   ⍝MAIN SIMULATION PROGRAM:  IF APPROPRIATE INFORMATION HAS PREVIOUSLY
[3]   ⍝BEEN SAVED AND IS AVAILABLE, IT IS NOT NECESSARY TO EXECUTE THIS
[4]   ⍝FUNCTION
[5]  START:'HOW MANY DIFFERENT FOREST TYPES COMPRISE THE AREA?'
[6]   G←⎕
[7]   'HOW MANY AGE CLASSES IS EACH FOREST TYPE COMPOSSED OF?'
[8]   A←⎕
[9]   'THEN, YOU WISH TO ENTER DATA FOR ',(2 0 ⍕G),' FOREST TYPES, EACH'
[10]  'COMPRISED OF ',(2 0 ⍕A),' AGE CLASSES, IS THAT CORRECT?  (Y OR N)'
[11]  →('N'∊⍞)/START
[12]  ' '
[13]  'TO ASSIGN DATA TO SOME VARIABLE, SIMPLY SUBSTITUTE ANY VARIABLE'
[14]  'NAME YOU WISH, FOR "ANYNAME", WHEN REQUESTED'
[15]  ' '
[16] ENTER:
[17]  ' '
[18]  'ORIGINAL FOREST COMPOSITION [C]'
[19]  'SUCCESSIONAL TRANSFER COEFICIENTS [S]'
[20]  'DISTURBANCE TRANSFER COEFICIENTS [D]'
[21]  'FIRE CONTROL COEFICIENTS [F]'
[22]  'LOGGING MATRIX [L]'
[23]  'LOGGING REGENERATION COEFICIENTS [R]'
[24]  ' '
```

```
[25] NEXT:'WHICH DATA SET DO YOU WISH TO ENTER?'
[26]  'ENTER ONE OF THE LETTERS IN BRACKETS'
[27]  T←⍞
[28]  →((ρT)>1)/REENTER
[29]  →((T='C'),(T='S'),(T='D'),(T='F'),(T='L'),(T='R'))/(FOR,SUC,DIST,FIR,LOGG,REG)
[30] REENTER:'YOU MUST ENTER ONE OF THE LETTERS IN BRACKETS'
[31]  →ENTER
[32] FOR:'TO ENTER ORIGINAL FOREST COMPOSITION, TYPE:  ANYNAME←ENTERFOREST'
[33]  ⍎⍞
[34]  →MORE
[35] SUC:'TO ENTER SUCCESSIONAL TRANSFER COEFICIENTS, TYPE:  ANYNAME←ENTERSUC'
[36]  ⍎⍞
[37]  →MORE
[38] DIST:'TO ENTER DISTURBANCE TRANSFER COEFICIENTS, TYPE:  ANYNAME←ENTERDIST'
[39]  ⍎⍞
[40]  →MORE
[41] FIR:'TO ENTER FIRE CONTROL COEFICIENTS, TYPE:  ANYNAME←ENTERFIRE'
[42]  ⍎⍞
[43]  →MORE
[44] LOGG:'TO ENTER LOGGING MATRIX, TYPE:  ANYNAME←ENTERLOG'
[45]  ⍎⍞
[46]  →MORE
[47] REG:'TO ENTER LOGGING REGENERATION COEFICIENTS, TYPE:  ANYNAME←ENTERREGEN'
[48]  ⍎⍞
[49]  →MORE
[50] MORE:'DO YOU WISH TO ENTER MORE DATA?  (Y OR N)'
[51]  →('Y'∊⍞)/NEXT
      ∇
      .


      ∇NULLPARAMETERS[⎕]∇
      ∇ NULLPARAMETERS
[1]  ⍝THIS FUNCTION INITIALIZES MATRIX VARIABLES OF REQUIRED
[2]  ⍝DIMENSIONS
[3]   SUCMATSTORE←(SETS,G,G,A)ρ0
[4]   DISTMATSTORE←(SETS,G,G,A)ρ0
[5]   FIREMATSTORE←(SETS,G,G,A)ρ0
[6]   LOGMATSTORE←(SETS,G,A)ρ0
[7]   LOGREGENMATSTORE←(SETS,G,G,A)ρ0
[8]   DEMANDSTORE←SETSρ0
      ∇
      .
```

```
∇ENTERSETS[⎕]∇
∇ ENTERSETS;NSET;SUCSUM
⍝THIS FUNCTION DIRECTS THE ASSIGNMENT OF VARIABLES REQUIRED
⍝DURING THE SIMULATION
 NSET←0
ENTER:NSET←NSET+1
 'ENTER PARAMETERS FOR ',(2 0 ⍕SETPERIODS[NSET]),' PERIOD'
 'SIMULATION SET ',(2 0 ⍕NSET)
 →(G=1)/SETSUC
 'WHICH SUCCESSIONAL TRANSFER MATRIX DO YOU WISH TO USE?'
 SUCMAT←⎕
DIST:'WHICH DISTURBANCE TRANSFER MATRIX DO YOU WISH TO USE?'
 DISTMAT←⎕
 'DO YOU WISH TO APPLY FIRE CONTROL?   (Y OR N)'
 FIRE←⍞
 →('N'∊FIRE)/NOFIRE
 'WHICH FIRE CONTROL MATRIX DO YOU WISH TO USE?'
 FIREMAT←⎕
LOGSTAND:
 'DO YOU WISH TO LOG THE STAND?   (Y OR N)'
 LOGIT←⍞
 →('N'∊LOGIT)/NOLOG
 'WHICH LOGGING MATRIX DO YOU WISH TO USE?'
 LOGMAT←⎕
 →(G=1)/SETREG
 'WHICH LOGGING REGENERATION MATRIX DO YOU WISH TO USE?'
 LOGREGENMAT←⎕
DEM:'WHAT IS THE DEMAND FOR TIMBER DURING THIS PERIOD?  (IN ACRES)'
 DEMAND←⎕
 →CHECKS
NOFIRE:FIREMAT←(G,G,A)⍴1
 →LOGSTAND
NOLOG:LOGMAT←(G,A)⍴0
 LOGREGENMAT←(G,G,A)⍴0
 DEMAND←0
CHECKS:
⍝CHECK THAT INPUT VARIABLES ARE OF APPROPRIATE DIMENSIONS
 DIMENSIONCHECK
 →(OUTERROR=1)/0
⍝APPLY FIRE CONTROL COEFICIENTS
 FIRECONTROL
⍝CHECK THAT INPUT VARIABLES ARE LOGICALLY REFINED
 LOGICHECK
 →(LOGICERROR=1)/0
```

```
[43] ⍝STORE INPUT PARAMETERS
[44]  ASSIGNPARAMETERS
[45]  →(NSET<SETS)/ENTER
[46]  →0
[47] SETSUC:SUCMAT←(G,G,A)⍴0
[48]  →DIST
[49] SETREG:LOGREGENMAT←(G,G,A)⍴1
[50]  →DEM
      ∇
      .

      ∇FIRECONTROL[⎕]∇
      ∇ FIRECONTROL;SUCSUM;RES;SUCPORTION;DELTASUC;DISTMINUS;BIN;RAVEL;DELTADIST;NEWDIST;NEWSUC
[1]   ⍝THIS FUNCTION CALCULATES THE AGE SPECIFIC DISTURBANCE COEFICIENTS
[2]   ⍝AND SUCCESSION COEFICIENTS, BASED ON THE EFFECTIVENESS OF FIRE CONTROL
[3]    SUCSUM←+/[1] SUCMAT
[4]    DISTSUM←+/[1] DISTMAT
[5]    RESUC←1-DISTSUM
[6]    SUCPORTION←(⍴SUCMAT)⍴SUCSUM÷RESUC
[7]    DELTASUC←SUCMAT÷(⍴SUCMAT)⍴((SUCSUM=0)+SUCSUM)
[8]    NEWDIST←DISTMAT×FIREMAT
[9]    NEWSUM←+/[1] NEWDIST
[10]   DELTADIST←NEWDIST÷(⍴NEWDIST)⍴((NEWSUM=0)+NEWSUM)
[11]   RAVEL←,NEWSUM
[12]   OVERDIST←RAVEL>1
[13]   RAVEL[OVERDIST/⍳(⍴RAVEL)]←1
[14]   NEWSUM←(⍴NEWDIST)⍴RAVEL
[15]   NEWDIST←DELTADIST×NEWSUM
[16]   DISTMINUS←DISTMAT-NEWDIST
[17]   NEWSUC←SUCMAT+((⍴DISTMINUS)⍴+/[1] DISTMINUS)×DELTASUC×SUCPORTION
[18]   SUCMAT←NEWSUC
[19]   DISTMAT←NEWDIST
       ∇
       .

       ∇ASSIGNPARAMETERS[⎕]∇
       ∇ ASSIGNPARAMETERS
[1]    ⍝THIS FUNCTION STORES SETS OF INPUT PARAMETERS AS THEY
[2]    ⍝ARE ENTERED
[3]     SUCMATSTORE[NSET;;;]←SUCMAT
[4]     DISTMATSTORE[NSET;;;]←DISTMAT
[5]     FIREMATSTORE[NSET;;;]←FIREMAT
[6]     LOGMATSTORE[NSET;;]←LOGMAT
[7]     LOGREGENMATSTORE[NSET;;;]←LOGREGENMAT
[8]     DEMANDSTORE[NSET]←DEMAND
        ∇
        .
```

```
    ∇DIMENSIONCHECK[⎕]∇
    ∇ DIMENSIONCHECK
   ⍝THIS FUNCTION CHECKS THAT DIMENSIONS OF INPUT PARAMETERS
   ⍝ARE COMPATABLE
    OUTERROR←0
   AA:→((⍴DISTMAT)≠G,G,A)/DISTOUTERROR
   B:→((⍴SUCMAT)≠G,G,A)/SUCOUTERROR
   C:→('Y'∊FIRE)/CHECKFIRE
   D:→('Y'∊LOGIT)/CHECKLOGA
    →0
   CHECKFIRE:→((⍴FIREMAT)≠G,G,A)/FIREOUTERROR
    →D
   CHECKLOGA:→((⍴LOGMAT)≠G,A)/LOGOUTERRORA
   CHECKLOGB:→((⍴LOGREGENMAT)≠G,G,A)/LOGOUTERRORB
    →0
   DISTOUTERROR:OUTERROR←1
    '***ERROR1***DISTURBANCE MATRIX HAS IMPROPER DIMENSIONS.  BASED ON INPUT '
    'FOREST MATRIX, DIMENSIONS SHOULD BE ',(2 0 ⍕G,G,A)
    →B
   SUCOUTERROR:OUTERROR←1
    '***ERROR2***SUCCESSION MATRIX HAS IMPROPER DIMENSIONS.  BASED ON INPUT'
    'FOREST MATRIX, DIMENSIONS SHOULD BE ',(2 0 ⍕G,G,A)
    →C
   FIREOUTERROR:OUTERROR←1
    '***ERROR3***FIRE CONTROL MATRIX HAS IMPROPER DIMENSIONS.  BASED ON INPUT'
    'FOREST MATRIX, DIMENSIONS SHOULD BE ',(2 0 ⍕G,G,A)
    →D
   LOGOUTERRORA:OUTERROR←1
    '***ERROR4***LOGGING MATRIX HAS IMPROPER DIMENSIONS.  BASED ON INPUT'
    'FOREST MATRIX, DIMENSIONS SHOULD BE ',(2 0 ⍕G,A)
    →CHECKLOGB
   LOGOUTERRORB:OUTERROR←1
    '***ERROR5***LOGGING REGENERATION MATRIX HAS IMPROPER DIMENSIONS.  BASED ON '
    'INPUT FOREST MATRIX, DIMENSIONS SHOULD BE ',(2 0 ⍕G,G,A)
    ∇
```

```
      ∇NEWSET[⎕]∇
      ∇ NEWSET
[1]   ⍝THIS FUNCTION INITIALIZES CURRENT INPUT PARAMETERS BY
[2]   ⍝ACCESSING SPECIFIC PORTIONS OF ENTIRE DATA SET
[3]    SETNUM←SETNUM+1
[4]    SUCMAT←SUCMATSTORE[SETNUM;;;]
[5]    DISTMAT←DISTMATSTORE[SETNUM;;;]
[6]    FIREMAT←FIREMATSTORE[SETNUM;;;]
[7]    LOGMAT←LOGMATSTORE[SETNUM;;]
[8]    LOGREGENMAT←LOGREGENMATSTORE[SETNUM;;;]
[9]    DEMAND←DEMANDSTORE[SETNUM]
      ∇
      .


      ∇FORNATURAL[⎕]∇
      ∇ FORNATURAL;TRANSUC;TRANSDIST;TRANSUCIN;TRANSUCOUT;TRANSDISTIN;TRANSDISTOUT
[1]   ⍝THIS FUNCTION APPLIES THE SUCCESSIONAL AND DISTURBANCE TRANSFER
[2]   ⍝COEFICIENTS TO THE CURRENT FOREST COMPOSITION TO ARRIVE AT A NEW
[3]   ⍝COMPOSITION.  IN DOING SO, IT ADVANCES ALL AGE CLASSES ONE PERIOD
[4]   ⍝INTO THE FUTURE
[5]   ⍝ASSIGN APPROPRIATE DIMENSIONS
[6]    TRANSUC←((G,G,A)ρCURRENT)×SUCMAT
[7]    TRANSDIST←((G,G,A)ρCURRENT)×DISTMAT
[8]   ⍝CALCULATE SUCCESSIONAL TRANSFERS INTO AGE CLASSES FOR EACH FOREST TYPE
[9]    TRANSUCIN←+/[2] TRANSUC
[10]  ⍝CALCULATE SUCCESSIONAL TRANSFERS OUT OF AGE CLASSES FOR FOREST TYPES
[11]   TRANSUCOUT←+/[1] TRANSUC
[12]  ⍝CALCULATE DISTURBANCE TRANSFERS INTO AGE CLASSES FOR EACH FOREST TYPE
[13]   TRANSDISTIN←+/[2] TRANSDIST
[14]  ⍝CALCULATE DISTURBANCE TRANSFERS OUT OF AGE CLASSES FOR FOREST TYPES
[15]   TRANSDISTOUT←+/[1] TRANSDIST
[16]  ⍝CALCULATE NEW FOREST COMPOSITION
[17]   CURRENT←CURRENT+TRANSUCIN-(TRANSUCOUT+TRANSDISTOUT)
[18]   TRANSDISTIN←+/[2] TRANSDISTIN
[19]   NEW←((¯1×(ρCURRENT)[1]),(¯1×(ρCURRENT)[2]))↑(0 ¯1 ↓CURRENT)
[20]   NEW[;1]←TRANSDISTIN
      ∇
      .
```

```
      ∇FORLOG[⎕]∇
      ∇ FORLOG;LOGABLEAGE;TOTALOGABLE;PORTIONSUPPLY;PORTIONHARVEST;LOGCLEAR;TRANSLOG;TRANSLOGIN;TRANSLOGOUT
[1]   ⍝THIS FUNCTION DIRECTS THE LOGGING PROCEDURE DURING THE SIMULATION
[2]   ⍝DETERMINE LOGABLE ACREAGE OF EACH AGE CLASS FOR ALL FOREST TYPES
[3]    LOGABLEAGE←LOGMAT×NEW
[4]   ⍝DETERMINE TOTAL LOGABLE ACREAGE FOR EACH FOREST TYPE
[5]    TOTALOGABLE←+/[2] LOGABLEAGE
[6]   ⍝SUM ALL FOREST TYPES TO DETERMINE TOTAL LOGABLE ACREAGE
[7]    SUPPLY←+/TOTALOGABLE
[8]   ⍝STORE THIS VALUE FOR FURTHER COMPUTATION
[9]    CURRENTSUPPLY←CURRENTSUPPLY,[1] SUPPLY
[10]   →(SUPPLY>DEMAND)/SURPLUS
[11]   →(SUPPLY<DEMAND)/DEFICIT
[12]  ⍝IF SUPPLY EXCEEDS DEMAND, DEMAND WILL BE MET
[13]  SURPLUS:HARVEST←DEMAND
[14]   →LOG
[15]  ⍝IF SUPPLY IS LESS THAN DEMAND, THEN HARVEST ALL THAT IS AVAILABLE
[16]  DEFICIT:HARVEST←SUPPLY
[17]   →LOG
[18]  LOG:
[19]  ⍝CALCULATE PROPORTION OF EACH FOREST TYPE TO BE LOGGED
[20]   PORTIONSUPPLY←TOTALOGABLE÷SUPPLY
[21]  ⍝CALCULATE ACREAGE TO BE LOGGED FROM EACH FOREST TYPE
[22]   PORTIONHARVEST←PORTIONSUPPLY×HARVEST
[23]  ⍝SELECT OLDEST AGE CLASSES TO BE LOGGED FIRST
[24]   LOGCLEAR←LOGAGE
[25]  CUT:
[26]  ⍝CALCULATE ACREAGE INVOLVED IN ALL TRANSFERS TO PIONEER CLASSES
[27]   TRANSLOG←((G,G,A)⍴LOGCLEAR)×LOGREGENMAT
[28]  ⍝CALCULATE TOTAL ACREAGE COMING INTO EACH AGE CLASS FOR FOREST TYPES
[29]   TRANSLOGIN←+/[2] TRANSLOG
[30]  ⍝CALCULATE TOTAL ACREAGE LEAVING EACH AGE CLASS FOR ALL FOREST TYPES
[31]   TRANSLOGOUT←+/[1] TRANSLOG
[32]  ⍝SUBTRACT LOGGED ACREAGE FROM AFFECTED AGE CLASSES
[33]   NEW←NEW-TRANSLOGOUT
[34]  ⍝CALCULATE TOTAL ACREAGE ENTERING EACH FOREST TYPE
[35]   TRANSLOGIN←+/[2] TRANSLOGIN
[36]  ⍝ADD LOGGED ACREAGE TO PIONEER AGE CLASSES
[37]   NEW[;1]←NEW[;1]+TRANSLOGIN
[38]  ⍝STORE LOGGED AREA FROM EACH AGE CLASS FOR ALL FOREST TYPES
[39]   LOGCOMP←LOGCOMP,[2](G,1,A)⍴LOGCLEAR
[40]  ⍝STORE TIMBER DEMAND FOR FURTHER COMPUTATION
[41]   CURRENTDEMAND←CURRENTDEMAND,[1] DEMAND
      ∇
```

```
      ∇LOGAGE[⎕]∇
      ∇ LOGCLEAR←LOGAGE;OLDAGE;HARVESTGROUPS;LIMIT;TAKEALL;REMAINDER;PARTIALIMIT;PARTIALOG
[1]   ⍝THIS FUNCTION ENSURES THAT FOR EACH FOREST GROUP, THE OLDEST
[2]   ⍝AGE CLASSES WILL BE LOGGED FIRST, AND THEN YOUNGER ONES
[3]   ⍝UNTIL THE HARVEST FOR EACH FOREST TYPE HAS BEEN SATISFIED
[4]    OLDAGE←⌽LOGABLEAGE
[5]    HARVESTGROUPS←⍉(A,G)⍴PORTIONHARVEST
[6]    LIMIT←(+\[2] OLDAGE)≤HARVESTGROUPS
[7]    TAKEALL←+/[2] LIMIT×OLDAGE
[8]    REMAINDER←PORTIONHARVEST-TAKEALL
[9]    LOGCLEAR←LIMIT×OLDAGE
[10]   PARTIALIMIT←1=+\[2] LIMIT=0
[11]   REMAINDER←⍉(A,G)⍴REMAINDER
[12]   PARTIALOG←PARTIALIMIT×REMAINDER
[13]   LOGCLEAR←⌽LOGCLEAR+PARTIALOG
      ∇
      .


      ∇PERCOMPOSITION[⎕]∇
      ∇ PERCOMPOSITION;TOTALCOMP
[1]   ⍝THIS FUNCTION CALCULATES THE PERCENTAGE OF TOTAL FORESTED
[2]   ⍝AREA OCCUPIED BY EACH FOREST TYPE DURING SIMULATION
[3]    TOTALCOMP←⍉(G,(⍴TOTALCOMP))⍴TOTALCOMP←+/[1] STAND[;;(A+1)]
[4]    PERCOMP←100×(⍉STAND[;;(A+1)])÷TOTALCOMP
[5]    PERCOMP←PERCOMP,[2] CURRENTSUPPLY,[2] TOTALCOMP[;1]
      ∇
      .


      ∇UPDATELOG[⎕]∇
      ∇ UPDATELOG;TOTALHAR;LOGICHAR
[1]   ⍝THIS FUNCTION CALCULATES THE TOTAL HARVEST FOR EACH FOREST TYPE
[2]   ⍝OVER THE ENTIRE SIMULATION PERIOD AND EXPRESSES THIS VALUE
[3]   ⍝AS A PERCENTAGE OF THE TOTAL HARVEST IN A GIVEN YEAR
[4]    LOGCOMP←LOGCOMP,[3]+/[3] LOGCOMP
[5]    TOTALHAR←⍉(G,(⍴TOTALHAR))⍴TOTALHAR←+/[1] LOGCOMP[;;(A+1)]
[6]    LOGICHAR←TOTALHAR
[7]    LOGICHAR[((TOTALHAR[;1]=0)/⍳(⍴TOTALHAR)[1]);]←1
[8]    PERHAR←100×(⍉LOGCOMP[;;(A+1)])÷LOGICHAR
[9]    PERHAR←PERHAR,[2] CURRENTDEMAND,[2] TOTALHAR[;1]
      ∇
      .
```

```
      ∇FORMATVARS[⎕]∇
      ∇ FORMATVARS
[1]   ⍝THIS FUNCTION INITIALIZES VARIABLES REQUIRED FOR FORMATING
[2]    NUMAGECLASS←(⍴TREES)[2]
[3]    AGECLASS←PERIODS×0,¯1+⍳NUMAGECLASS
[4]    TRANSFERLABELS←(G,G,1)⍴GROUPLABELS
[5]    TRANSFERLABELS←TRANSFERLABELS,[3](G,G,1)⍴⍉TRANSFERLABELS
[6]    GROUPLIST←((⍴GROUPLABELS)[1])⍴⍉GROUPLABELS
[7]    YEARS←((Y+1),1)⍴0,⍳Y
      ∇
      .

      ∇FORMTREE[⎕]∇
      ∇ HEADING FORMTREE MATRIX;LISTEMP;COLFORMAT;ROWFORMAT;ROWLIST;COLTYPE;COLTITLE;COLHEADER1;COLHEADER2;ROWHEADER;K
[1]   ⍝THIS FUNCTION FORMATS ORIGINAL FOREST COMPOSITION AND HARVESTABLE
[2]   ⍝TIMBER DATA SETS
[3]    K←PAGECOLS
[4]    LISTEMP←AGECLASS
[5]    COLFORMAT←(9 0 ⍕11111110),' +'
[6]    ROWFORMAT←'11111111100'
[7]    ROWLIST←GROUPLABELS
[8]    COLTYPE←0
[9]    COLTITLE←'A G E     C L A S S E S'
[10]   COLHEADER1←''
[11]   COLHEADER2←''
[12]   ROWHEADER←'FOREST TYPE'
[13]   HEADING FMAT2 MATRIX
      ∇
      .

      ∇FMAT2[⎕]∇
      ∇ HEADING FMAT2 MATRIX;NUMCOLS;MATEMP;FIRST;ROWTITLE;ROWLINE;HEAD1;HEAD2
[1]   ⍝THIS GENERAL FUNCTION PERFORMS THE BASIC FORMATING OF ALL DATA SETS
[2]    '1' FMT 1 1 ⍴0
[3]    HEADING
[4]    '1' FMT 2 1 ⍴0
[5]    NUMCOLS←COLTYPE+((⍴⍴LISTEMP)=0)+⍴LISTEMP
[6]    MATEMP←MATRIX
[7]    FIRST←'Y'
```

```
[8]  PRINTMORE:
[9]   ROWTITLE←11ρ' '
[10]  ROWLINE←12ρ' '
[11]  HEAD1←''
[12]  HEAD2←''
[13]  →((NUMCOLS=1),((NUMCOLS=R+1)∧(COLTYPE=2)),((NUMCOLS≤R)∧(NUMCOLS>1)))/PRINTONE,PRINTSOME,PRINTALL
[14]  →('Y'∊FIRST)/HEADERS
[15] PRINT:
[16]  (ROWTITLE,((11×R-(((ρHEAD1)≠0)+((ρHEAD2)≠0)))ρCOLFORMAT),HEAD1,HEAD2) FMT(R-(((ρHEAD1)≠0)+((ρHEAD2)≠0)))↑LISTEMP
[17]  (ROWLINE,' '),((11×R)ρ'-')
[18]  (ROWFORMAT FMT ROWLIST),'|',(11 2 ⍕MATEMP[;⍳R])
[19]  '1' FMT 2 1 ρ0
[20]  LISTEMP←(R-(((ρHEAD1)≠0)+((ρHEAD2)≠0)))↓LISTEMP
[21]  MATEMP←(0,R)↓MATEMP
[22]  NUMCOLS←NUMCOLS-R
[23]  →(NUMCOLS>0)/PRINTMORE
[24]  →0
[25] PRINTALL:R←NUMCOLS
[26]  HEAD1←COLHEADER1
[27]  HEAD2←COLHEADER2
[28]  →('Y'∊FIRST)/HEADERS
[29]  →PRINT
[30] PRINTSOME:
[31]  HEAD1←COLHEADER1
[32]  →('Y'∊FIRST)/HEADERS
[33]  →PRINT
[34] PRINTONE:R←NUMCOLS
[35]  HEAD2←COLHEADER2
[36]  →PRINT
[37] HEADERS:
[38]  ((12+4×R)ρ' '),COLTITLE
[39]  ROWTITLE←ROWHEADER
[40]  ROWLINE←12ρ'-'
[41]  FIRST←'N'
[42]  →PRINT
      ∇
```

```
      ∇FORMATSIM[⎕]∇
      ∇ FORMATSIM;PRINTINPUT;PAGECOLS;GROUPLABELS;PERIODS;NUMAGECLASS;AGECLASS;TRANSFERLABELS;GROUPLIST;YEARS;I;FURLABEL
        S
[1]   ⍝THIS FUNCTION DIRECTS THE PRESENTATION OF SIMULATION RESULTS
[2]    ⎕PW←140
[3]    FORMATQUEST
[4]    (11+11×PAGECOLS)⍴'*'
[5]    '1' FMT 2 1 ⍴0
[6]    ('FOREST GROWTH SIMULATION FOR '),(2 0 ⍕Y),(' PERIODS OF '),(2 0 ⍕PERIODS),(' YEARS EACH')
[7]    →('N'∊PRINTINPUT)/RESULTS
[8]    '1' FMT 3 1 ⍴0
[9]    'INPUT INFORMATION'
[10]   (11+11×PAGECOLS)⍴'¯'
[11]   'ORIGINAL FOREST COMPOSITION' FORMTREE TREES
[12]  NEXT:I←0
[13]  PRINTPARAMETERS:I←I+1
[14]   '1' FMT 4 1 ⍴0
[15]   'SIMULATION PARAMETERS FOR ',(2 0 ⍕SETPERIODS[I]),' YEAR SIMULATION SET ',(2 0 ⍕I),' ',10⍴'←'
[16]   →(~(1∊(FIREMATSTORE[I;;]≠1)))/NOCONTROL
[17]   'FIRE CONTROL COEFICIENTS' FORMTRANSFER FIREMATSTORE[I;;;]
[18]   →((+/⍴GROUPLABELS)=2)/DISTFIRE
[19]   'SUCCESSIONAL TRANSFER COEFICIENTS WITH FIRE CONTROL' FORMTRANSFER SUCMATSTORE[I;;;]
[20]  DISTFIRE:'DISTURBANCE TRANSFER COEFICIENTS WITH FIRE CONTROL' FORMTRANSFER DISTMATSTORE[I;;;]
[21]   →LOGCONTROL
[22]  NOCONTROL:→((+/⍴GROUPLABELS)=2)/DIST
[23]   'SUCCESSIONAL TRANSFER COEFICIENTS' FORMTRANSFER SUCMATSTORE[I;;;]
[24]  DIST:'NATURAL DISTURBANCE TRANSFER COEFICIENTS' FORMTRANSFER DISTMATSTORE[I;;;]
[25]  LOGCONTROL:→(~(1∊(LOGMATSTORE[I;;]≠0)))/NOLOG
[26]   'HARVESTABLE TIMBER IN THE VARIOUS FOREST GROUPS' FORMTREE LOGMATSTORE[I;;]
[27]   →((+/⍴GROUPLABELS)=2)/NOLOG
[28]   'REGENERATION TRANSFER COEFICIENTS AFTER LOGGING' FORMTRANSFER LOGREGENMATSTORE[I;;;]
[29]  NOLOG:→(I<SETS)/PRINTPARAMETERS
[30]  RESULTS:
[31]   '1' FMT 6 1 ⍴0
[32]   'RESULTS OF SIMULATION'
[33]   (11+11×PAGECOLS)⍴'¯'
[34]   'PERCENTAGE COMPOSITION OF FOREST TYPES DURING SIMULATION PERIOD' FORMCOMP PERCOMP
[35]   'AGE DISTRIBUTION OF FOREST AREA IN ACRES' FORMAGEDIST AGEDIST
[36]   'AGE DISTRIBUTION OF FOREST AREA AS PERCENTAGE' FORMAGEDIST PERCENTAGEDIST
[37]   →(~(1∊(LOGMATSTORE≠0)))/NOTHINGLOGGED
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[38]  'PERCENTAGE HARVEST OBTAINED FROM EACH FOREST TYPE' FORMLOGCOMP PERHAR
[39] NOTHINGLOGGED:
[40]  →((+/ρGROUPLABELS)=2)/END
[41]  '1' FMT 4 1 ρ0
[42]  'AREA OCCUPIED BY EACH AGE CLASS OF ALL FOREST GROUPS DURING SIMULATION'
[43]  GROUPLIST FORMGROUPS STAND
[44] END:'1' FMT 3 1 ρ0
[45]  (11+11×PAGECOLS)ρ'*'
[46]  →0
      ∇
      .


      ∇FORMATQUEST[⎕]∇
      ∇ FORMATQUEST
[1]  ⍝THIS FUNCTION ALLOWS THE USER TO SPECIFY OUTPUT OPTIONS DESIRED
[2]  ENTER:'ENTER NUMERIC FOREST GROUP LABELS (2 DIGITS MAXIMUM)'
[3]   GROUPLABELS←⎕
[4]   →((ρρGROUPLABELS)=0)/RESIZE
[5]  GROUPCHECK:
[6]   →(~(0∊((ρGROUPLABELS)≠(ρTREES)[1])))/GROUPLABELERROR
[7]   GROUPLABELS←((ρGROUPLABELS),1)ρGROUPLABELS
[8]   'HOW MANY YEARS LONG IS EACH AGE CLASS?'
[9]   PERIODS←⎕
[10]  FORMATVARS
[11]  'DO YOU WISH TO HAVE THE INPUT INFORMATION PRINTED OUT?    (Y OR N)'
[12]  PRINTINPUT←⍞
[13]  'DO YOU WISH TO HAVE THE RESULTS FOR ALL ',(2 0 ⍕Y),' PERIODS'
[14]  'PRINTED?  (Y OR N)'
[15]  →('Y'∊⍞)/PRINTALL
[16]  'FOR WHICH PERIODS DO YOU WISH TO SEE THE RESULTS?'
[17]  PRINTYEARS←1,1+⎕
[18]  →PRINT
[19] PRINTALL:PRINTYEARS←⍳Y+1
[20] PRINT:'HOW WIDE IS THE OUTPUT PAPER?   (IN INCHES)'
[21]  PAGECOLS←(⌊⎕+0.5)-2
[22]  ⎕PW←200
[23]  'POSITION PAPER FOR OUTPUT, THEN HIT RETURN'
[24]  ⍞
[25]  →0
[26] GROUPLABELERROR:'NUMBER OF GROUP LABELS ENTERED DOES NOT CORRESPOND TO THOSE IN INPUT MATRIX'
[27]  →ENTER
[28] RESIZE:GROUPLABELS←1ρGROUPLABELS
[29]  →GROUPCHECK
      ∇
      .
```

```
      ∇FORMTRANSFER[⎕]∇
      ∇ HEADING FORMTRANSFER MATRIX;NUMAGETEMP;AGETEMP;MATEMP;R;FIRST;ROWTITLE;ROWLINE
[1]   ⍝THIS FUNCTION FORMATS THE DISTURBANCE, SUCCESSIONAL, REGENERATION, AND FIRE
[2]   ⍝CONTROL COEFICIENT DATA SETS
[3]    R←PAGECOLS
[4]    '1' FMT 1 1 ⍴0
[5]    HEADING
[6]    '1' FMT 2 1 ⍴0
[7]    NUMAGETEMP←NUMAGECLASS
[8]    AGETEMP←AGECLASS
[9]    MATEMP←MATRIX
[10]   FIRST←'Y'
[11]  PRINTMORE:
[12]   ROWTITLE←11⍴' '
[13]   ROWLINE←12⍴' '
[14]   →(NUMAGETEMP≤R)/PRINTALL
[15]   →('Y'∊FIRST)/HEADERS
[16]  PRINT:
[17]   (ROWTITLE,((11×R)⍴(9 0 ⍕11111110),' +')) FMT R↑AGETEMP
[18]   (ROWLINE,' '),((11×R)⍴'-')
[19]   ('100 11111100' FMT TRANSFERLABELS),'|',(11 3 ⍕MATEMP[;;⍳R])
[20]   '1' FMT 2 1 ⍴0
[21]   AGETEMP←R↓AGETEMP
[22]   MATEMP←(0,0,R)↓MATEMP
[23]   NUMAGETEMP←NUMAGETEMP-R
[24]   →(NUMAGETEMP>0)/PRINTMORE
[25]   →0
[26]  PRINTALL:R←NUMAGETEMP
[27]   →('Y'∊FIRST)/HEADERS
[28]   →PRINT
[29]   →0
[30]  HEADERS:
[31]   ((12+R×4)⍴' '),'A G E     C L A S S E S'
[32]   ROWTITLE←' TRANSFERS '
[33]   ROWLINE←12⍴'-'
[34]   FIRST←'N'
[35]   →PRINT
      ∇
```

```
     ∇FORMCOMP[⎕]∇
     ∇ HEADING FORMCOMP MATRIX;LISTEMP;COLFORMAT;ROWLIST;COLTYPE;COLTITLE;COLHEADER1;COLHEADER2;ROWHEADER;R
[1]  ⍝THIS FUNCTION FORMATS THE PERCENTAGE COMPOSITION OF EACH FOREST GROUP
[2]  ⍝DURING THE SIMULATION
[3]   R←PAGECOLS
[4]   LISTEMP←GROUPLIST
[5]   COLFORMAT← 11 0 ⍕111111100
[6]   ROWFORMAT←'111111111110'
[7]   ROWLIST←YEARS[PRINTYEARS;]
[8]   COLTYPE←2
[9]   COLTITLE←'F O R E S T     G R O U P S'
[10]  COLHEADER1←'      TIMBER'
[11]  COLHEADER2←'       TOTAL'
[12]  ROWHEADER←'  PERIOD   '
[13]  HEADING FMAT2 MATRIX[PRINTYEARS;]
     ∇
     .

     ∇FORMLOGCOMP[⎕]∇
     ∇ HEADING FORMLOGCOMP MATRIX;LISTEMP;COLFORMAT;ROWFORMAT;ROWLIST;COLTYPE;COLTITLE;COLHEADER1;COLHEADER2;ROWHEADER;
       R
[1]  ⍝THIS FUNCTION FORMATS THE PERCENTAGE HARVEST OBTAINED FROM EACH FOREST GROUP
[2]  ⍝DURING THE SIMULATION
[3]   R←PAGECOLS
[4]   LISTEMP←GROUPLIST
[5]   COLFORMAT← 11 0 ⍕111111100
[6]   ROWFORMAT←'111111111110'
[7]   ROWLIST←YEARS[PRINTYEARS;]
[8]   COLTYPE←2
[9]   COLTITLE←'F O R E S T     G R O U P S'
[10]  COLHEADER1←'      DEMAND'
[11]  COLHEADER2←'       TOTAL'
[12]  ROWHEADER←'  PERIOD   '
[13]  HEADING FMAT2 MATRIX[PRINTYEARS;]
     ∇
     .
```

```
      ∇FORMAGEDIST[⎕]∇
      ∇ HEADING FORMAGEDIST MATRIX;COLFORMAT;ROWFORMAT;ROWLIST;COLTYPE;COLTITLE;COLHEADER1;COLHEADER2;ROWHEADER;LISTEMP
[1]   ⍝THIS FUNCTION FORMATS THE AGE DISTRIBUTION OF THE ENTIRE FOREST
[2]    R←PAGECOLS
[3]    '1' FMT 4 1 ρ0
[4]    COLFORMAT←(9 0 ▼11111110),' +'
[5]    ROWFORMAT←'111111111110'
[6]    ROWLIST←YEARS[PRINTYEARS;]
[7]    COLTYPE←1
[8]    COLTITLE←'A G E     C L A S S E S'
[9]    COLHEADER1←''
[10]   COLHEADER2←'        TOTAL'
[11]   ROWHEADER←'  PERIOD   '
[12]   LISTEMP←AGECLASS
[13]   HEADING FMAT2 MATRIX[PRINTYEARS;]
      ∇
      .

      ∇FORMGROUPS[⎕]∇
      ∇ HEADING FORMGROUPS STAND;COLFORMAT;ROWFORMAT;ROWLIST;COLTYPE;COLHEADER1;COLHEADER2;ROWHEADER;LISTEMP;R;COLTITLE
[1]   ⍝THIS FUNCTION PROVIDES DETAILED FORMATING OF EACH AGE GROUP OF ALL FOREST TYPES
[2]    '1' FMT 6 1 ρ0
[3]    N←0
[4]    COLFORMAT←(9 0 ▼11111110),' +'
[5]    ROWFORMAT←'111111111110'
[6]    ROWLIST←YEARS[PRINTYEARS;]
[7]    COLTYPE←1
[8]    COLTITLE←'A G E     C L A S S E S'
[9]    COLHEADER1←''
[10]   COLHEADER2←'        TOTAL'
[11]   ROWHEADER←'  PERIOD   '
[12]  LOOP:N←N+1
[13]   R←PAGECOLS
[14]   LISTEMP←AGECLASS
[15]   MATRIX←STAND[N;;]
[16]   '1' FMT 2 1 ρ0
[17]   ('FOREST TYPE'),('_00' FMT HEADING[N])
[18]   '' FMAT2 MATRIX[PRINTYEARS;]
[19]   →(N<(ρHEADING)[1])/LOOP
      ∇
      .
```

```
      ∇FMT[⎕]∇
      ∇ Z←P FMT N;DC;DEC;DCT;DP;LP;NFW;DD;NSF;RR;RS;ZIX;I;Q;R;S;T;U;V;W;⎕IO
[1]   ⍝THIS FORMATING FUNCTION IS A GENERALLY AVAILABLE ROUTINE UNDER V S APL AT THE
[2]   ⍝UNIVERISITY OF WATERLOO, WATERLOO, ONTARIO
[3]    ⎕IO←~I←0
[4]    RR←⍴RS←⍴N
[5]    N←(¯2↑1,(×/¯1↓RS),(RR-1)↑RS)⍴N
[6]    LP←⍳''⍴⍴P←' ',P,' '
[7]   ⍝    ANALYZE PATTERN
[8]    DGT←(P∊DC←'0123456789')/LP
[9]    NFW←(Q≠0)/Q←(1↓T)-¯1↓T←+/((P=' ')/LP)∘.>DGT
[10]   →((¯1↑⍴N)=⍴NFW)/2+⎕LC
[11]   →0=⍴⎕←'LENGTH ERROR'
[12]   NSF←DGT[(T-NFW-1),[1.1] T←+\NFW]
[13]   S←1=+⌿T←≠/(Q←(P='.')/LP)∘.≥(NSF[;,1]-1),NSF[;2]
[14]   Q←S\(∨/S/T)/Q
[15]   DP←0≠DEC←Q×(T←Q=NSF[;1]-1)∨∧/(Q∘.+ ¯1 1)∊DGT
[16]   DEC←DEC+(~DP)×1+NSF[;2]
[17]   NSF[;1]←NSF[;1]-T
[18]  ⍝    GENERATE REPRESENTATION
[19]   Z←((1↑⍴N),⍴P)⍴P
[20]   DD←(Q←(NFW+DP),[1.1]+⌿≠/DGT∘.≥DEC,1+NSF[;,2])[;2]
[21]   Z[;T[⍋T←DGT,DP/DEC]]←(,Q)⍕|N
[22]  ⍝    ADJUST LEADING ZEROS
[23]   S←∨⌿T←<\≠/(ZIX←(P='0')/LP)∘.≥NSF[;,1],DEC
[24]   →(0=⍴Q←(U←~S∨DP)/NSF[;2])/L1
[25]   Z[;Q]←((0=⌊0.5+|U/N)⌽Z[;Q],[2.1] ' ')[;;1]
[26]  L1:→(0=1↑⍴T←S⌿(DEC-1),[1.1] S\(∨/T)/ZIX)/L2
[27]   Q←(Q∊DGT)/Q←(,Q∘.≥S)/,T[;2]∘.+S←¯1+⍳1+⌈/Q←-/T
[28]   Z[;Q]←U[2⌊(U←' ',DC)⍳Z[;Q]]
[29]  ⍝    REMOVE TRAILING ZEROS
[30]  L2:ZIX←ZIX[⍋ZIX←ZIX,DP/DEC]
[31]   T←⊖<\⊖≠/ZIX∘.≥DEC,NSF[;,2]+1
[32]   →(0=1↑⍴Q←(0<-/Q)⌿Q←((∨⌿T)⌿NSF[;,2]),(∨/T)/ZIX)/L3
[33]   T←(1+Q[;1])∘.-⍳⌈/-/Q
[34]   T←T×P[T]∊DC
[35]   Q←1,((⍴T)⍴(,T)[⍒, 1 2 1 ⍉T∘.+(⍴P)×⍳(⍴T)[1]]),⌽Q[;2]
[36]  R1:→(0=×/⍴Q←(U←∨⌿T←Z[;Q[; 2 1]]∧.='0 ')⌿Q)/L3
[37]   Z[;Q[;2]]←((U/T)⌽Z[;Q[;2]],[2.1] ' ')[;;1]
[38]   Q← 0 1 ↓Q
[39]   →(0≠1↑⍴Q←(0<-/Q[;2,(⍴Q)[2]])⌿Q)/R1
[40]  ⍝    REMOVE COMMAS AND TRAILING DECIMAL POINTS
[41]  L3:→(0=⍴Q←(∨/≠/T∘.≥NSF)/T←(P=',')/LP)/L4
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[42]  →(0=ρQ←(∧/P[Q∘.+ ¯1 1]∊DC)/Q)/L4
[43]  Z[;Q]←' .'[1+∧/Z[;Q∘.+ ¯1 1]∊DC]
[44] L4:→(0=ρQ←DP/DEC)/L5
[45]  Z[;Q]←' .'[1+Z[;Q+1]∊DC]
[46] ⍝     PROCESS NEGATIVE SYMBOLS
[47] L5:→(∧/' '∧.=P[1 2 1 ⍉ ¯1 1 ∘.+NSF])/L6
[48]  U←(N<0)∧0≠⌊0.5+(|N)×(ρN)ρ10*DD
[49] R2:→(3=I←1-2×I)/L6
[50]  R←×Q←NSF[;1⌈2×I]
[51] R3:→(0=ρV←(R←R∧P[Q]≠' ')/Q←Q+I×R)/R2
[52]  Z[;V]←((~S←R/U)⌽Z[;V],[2.1] ' ')[;;1]
[53] R4:→(~∨/T←V≠S←S∧Z[;V←V-I]=' ')/R3
[54]  Z[;W]←(S←T/S)⌽Z[;W←V,[1.1] I+V←T/V]
[55]  →R4
[56] ⍝     ADJUST SIZE AND RANK OF RESULT
[57] L6:Z← 0 1 ↓ 0 ¯1 ↓Z
[58]  →(2=RR)/0
[59]  Z←((¯1↑RS), 1↑ρZ)ρZ
     ∇
     .


     ∇ENTERFOREST[⎕]∇
     ∇ MAT←ENTERFOREST
[1]  ⍝THIS FUNCTION ENABLES THE USER TO ENTER THE ORIGINAL FOREST
[2]  ⍝COMPOSITION
[3]   MAT←ENTER2MAT
     ∇
     .


     ∇ENTERSUC[⎕]∇
     ∇ MAT←ENTERSUC
[1]  ⍝THIS FUNCTION ENABLES THE USER TO ENTER SUCCESSIONAL TRANSFER
[2]  ⍝COEFICIENTS
[3]   'SUCCESSIONAL TRANSFERS WITHIN THE SAME FOREST GROUP CANNOT LOGICALLY OCCUR, THEREFORE THESE'
[4]   'COEFICIENTS HAVE BEEN ASSIGNED THE VALUE 0.'
[5]   MAT←ENTER3MAT
     ∇
     .
```

```
      ∇ENTERDIST[⎕]∇
      ∇ MAT←ENTERDIST
[1]   ⍝THIS FUNCTION ENABLES THE USER TO ENTER DISTURBANCE TRANSFER
[2]   ⍝COEFICIENTS
[3]    MAT←ENTER3MAT
      ∇
      .

      ∇ENTERFIRE[⎕]∇
      ∇ MAT←ENTERFIRE
[1]   ⍝THIS FUNCTION ENABLES THE USER TO ENTER FIRE CONTROL COEFICIENTS
[2]    MAT←ENTER3MAT
      ∇
      .

      ∇ENTERLOG[⎕]∇
      ∇ MAT←ENTERLOG
[1]   ⍝THIS FUNCTION ENABLES THE USER TO ENTER LOGGING MATRIX DATA
[2]    MAT←ENTER2MAT
      ∇
      .

      ∇ENTERREGEN[⎕]∇
      ∇ MAT←ENTERREGEN
[1]   ⍝THIS FUNCTION ENABLES THE USER TO ENTER LOGGING REGENERATION
[2]   ⍝TRANSFER COEFICIENTS
[3]    MAT←ENTER3MAT
      ∇
      .
```

```
      ∇ENTER2MAT[⎕]∇
      ∇ MAT←ENTER2MAT;N;ROW
[1]   ⍝THIS FUNCTION DIRECTS THE ASSIGNMENT OF THE ORIGINAL FOREST
[2]   ⍝COMPOSITION AND THE LOGGING MATRIX TO DESIRED VARIABLES
[3]    MAT←(G,A)⍴0
[4]    N←0
[5]   ENTER:N←N+1
[6]   REENTER:'ENTER DATA FOR FOREST TYPE ',(2 0 ⍕N)
[7]    ROW←⎕
[8]    →(~(0∊((⍴ROW)≠A)))/AGERROR
[9]    →(T='L')/LOGTYPE
[10]  ASSIGN:MAT[N;]←ROW
[11]   →(N<G)/ENTER
[12]   →0
[13]  AGERROR:'YOU MUST ENTER ',(2 0 ⍕A),' NUMBERS'
[14]   →REENTER
[15]  LOGTYPE:→(~(((ROW=1)+(ROW=0))≠1))/ASSIGN
[16]   'NUMBERS ENTERED MUST BE ONLY 1 OR 0 SINCE THIS BINARY CHOICE SIMPLY'
[17]   'INDICATES WHETHER A PARTICULAR AGE CLASS AND FOREST TYPE IS LOGABLE'
[18]   'OR NOT'
[19]   →REENTER
      ∇
```

```
      ∇ENTER3MAT[⎕]∇
      ∇ MAT←ENTER3MAT;COMP;ROW;PAGE
[1]   ⍝THIS FUNCTION DIRECTS THE ASSIGNMENT OF SUCCESSIONAL TRANSFER
[2]   ⍝COEFICIENTS, DISTURBANCE TRANSFER COEFICIENTS, FIRE CONTROL
[3]   ⍝COEFICIENTS, AND LOGGING REGENERATION COEFICIENTS AS REQUIRED
[4]    MAT←(G,G,A)⍴0
[5]    PAGE←0
[6]   PAGELOOP:PAGE←PAGE+1
[7]    ROW←0
[8]   ROWLOOP:ROW←ROW+1
[9]    →(T='S')/SUCTYPE
[10]  REENTER:'ENTER TRANSFERS FOR ALL ',(2 0 ⍕A),' AGE CLASSES FOR FOREST'
[11]   'TYPE ',(2 0 ⍕ROW),' TO FOREST TYPE ',(2 0 ⍕PAGE)
[12]   COMP←⎕
[13]   →(~(0∊((⍴COMP)≠A)))/ENTERERROR
[14]   →(T='F')/FIRTYPE
[15]  ASSIGN:MAT[PAGE;ROW;]←COMP
[16]  DECISION:→(ROW<G)/ROWLOOP
[17]   →(PAGE<G)/PAGELOOP
[18]   →0
[19]  ENTERERROR:'YOU MUST ENTER ',(2 0 ⍕A),' NUMBERS'
[20]   →REENTER
[21]  SUCTYPE:→(ROW=PAGE)/DECISION
[22]   →REENTER
[23]  FIRTYPE:→(~(( 1↑COMP)≠0))/ASSIGN
[24]   'THE LAST NUMBER IN THE VECTOR ENTERED MUST LOGICALLY = 0, SINCE THE'
[25]   'MAXIMUM AGE OF THE FOREST HAS BEEN SPECIFIED, MEANING THAT AT THIS AGE,'
[26]   'EVERYTHING DIES.  SINCE THE FIRE CONTROL COEFICIENTS ACT TO DECREASE'
[27]   'THE NATURAL DISTURBANCE COEFICIENTS, THIS COULD RESULT IN A SITUATION'
[28]   'WHERE SOMETHING LESS THAN TOTAL DISTURBANCE OCCURRED IN THE MAXIMUM'
[29]   'AGE CLASS, UNLESS FIRE CONTROL COEFICIENTS IN THE MAXIMUM AGE CLASS'
[30]   'ARE ZERO.'
[31]   →REENTER
      ∇
```

EXAMPLE PROGRAM RUN

[illegible] (I. ACRES)

500

[illegible] (2 [illegible])

1 2 3 4 5 6

[illegible] AGE CLASS?

20

DO YOU [illegible] (Y [illegible])

Y

DO YOU [illegible] ALL 25 PERIODS [illegible]? (Y OR N)

FOR WHICH PERIODS DO YOU [illegible]?

1 5 10 15 20 25

HOW [illegible] (IN [illegible])

14

[illegible] FOR [illegible]

****

[illegible] GROWTH SIMULATION FOR 25 PERIODS OF 20 YEARS EACH

[illegible]

[illegible]

[illegible]	0 +	20 +	40 +	60 +	80 +	100 +	120 +	140 +	160 +
	AGE CLASSES								
01	500.00	281.00	275.00	215.00	.00	.00	.00	.00	.00
02	1716.00	1556.00	1616.00	876.00	144.00	.00	.00	.00	.00
03	303.00	291.00	285.00	232.00	63.00	.00	.00	.00	.00
04	94.00	52.00	51.00	430.00	374.00	102.00	13.00	.00	.00
05	110.00	106.00	104.00	53.00	93.00	.00	.00	.00	.00
06	.00	.00	.00	15.00	22.00	33.00	5.00	.00	.00

[illegible]

[illegible]

[illegible]		0 +	20 +	40 +	60 +	80 +	100 +	120 +	140 +	160 +
01	01	.200	.200	.200	.200	.200	.200	.200	.200	1.000
02	01	.200	.200	.200	.200	.200	.200	.200	.200	1.000
03	01	.200	.200	.200	.200	.200	.200	.200	.200	1.000
04	01	.200	.200	.200	.200	.200	.200	.200	.200	1.000
05	01	.200	.200	.200	.200	.200	.200	.200	.200	1.000
06	01	.200	.200	.200	.200	.200	.200	.200	.200	1.000
01	02	.200	.200	.200	.200	.200	.200	.200	.200	1.000
02	02	.200	.200	.200	.200	.200	.200	.200	.200	1.000
03	02	.200	.200	.200	.200	.200	.200	.200	.200	1.000
04	02	.200	.200	.200	.200	.200	.200	.200	.200	1.000
05	02	.200	.200	.200	.200	.200	.200	.200	.200	1.000
06	02	.200	.200	.200	.200	.200	.200	.200	.200	1.000
01	03	.200	.200	.200	.200	.200	.200	.200	.200	1.000
02	03	.200	.200	.200	.200	.200	.200	.200	.200	1.000
03	03	.200	.200	.200	.200	.200	.200	.200	.200	1.000
04	03	.200	.200	.200	.200	.200	.200	.200	.200	1.000
05	03	.200	.200	.200	.200	.200	.200	.200	.200	1.000
06	03	.200	.200	.200	.200	.200	.200	.200	.200	1.000
01	04	.200	.200	.200	.200	.200	.200	.200	.200	1.000
02	04	.200	.200	.200	.200	.200	.200	.200	.200	1.000
03	04	.200	.200	.200	.200	.200	.200	.200	.200	1.000
04	04	.200	.200	.200	.200	.200	.200	.200	.200	1.000
05	04	.200	.200	.200	.200	.200	.200	.200	.200	1.000
06	04	.200	.200	.200	.200	.200	.200	.200	.200	1.000
01	05	.200	.200	.200	.200	.200	.200	.200	.200	1.000
02	05	.200	.200	.200	.200	.200	.200	.200	.200	1.000
03	05	.200	.200	.200	.200	.200	.200	.200	.200	1.000
04	05	.200	.200	.200	.200	.200	.200	.200	.200	1.000
05	05	.200	.200	.200	.200	.200	.200	.200	.200	1.000
06	05	.200	.200	.200	.200	.200	.200	.200	.200	1.000
01	06	.200	.200	.200	.200	.200	.200	.200	.200	1.000
02	06	.200	.200	.200	.200	.200	.200	.200	.200	1.000
03	06	.200	.200	.200	.200	.200	.200	.200	.200	1.000
04	06	.200	.200	.200	.200	.200	.200	.200	.200	1.000
05	06	.200	.200	.200	.200	.200	.200	.200	.200	1.000
06	06	.200	.200	.200	.200	.200	.200	.200	.200	1.000

		0 +	20 +	40 +	60 +	80 +	100 +	120 +	140 +	160 +
01	01	.000	.000	.000	.000	.000	.000	.000	.000	.000
02	01	.000	.000	.000	.000	.000	.000	.000	.000	.000
03	01	.000	.000	.000	.000	.000	.000	.000	.000	.000
04	01	.000	.000	.000	.000	.000	.000	.000	.000	.000
05	01	.000	.000	.000	.000	.000	.000	.000	.000	.000
06	01	.000	.000	.000	.000	.000	.000	.000	.000	.000
01	02	.000	.000	.000	.000	.000	.000	.000	.000	.000
02	02	.000	.000	.000	.000	.000	.000	.000	.000	.000
03	02	.000	.000	.000	.000	.000	.000	.000	.000	.000
04	02	.000	.000	.000	.000	.000	.000	.000	.000	.000
05	02	.000	.000	.000	.000	.000	.000	.000	.000	.000
06	02	.000	.000	.000	.000	.000	.000	.000	.000	.000
01	03	.000	.000	.000	.000	.000	.000	.000	.000	.000
02	03	.000	.000	.000	.000	.000	.000	.000	.000	.000
03	03	.000	.000	.000	.000	.000	.000	.000	.000	.000
04	03	.000	.000	.000	.000	.000	.000	.000	.000	.000
05	03	.000	.000	.000	.000	.000	.000	.000	.000	.000
06	03	.000	.000	.000	.000	.000	.000	.000	.000	.000
01	04	.000	.000	.000	.000	.000	.000	.000	.000	.000
02	04	.000	.000	.233	.260	.387	.000	.000	.000	.000
03	04	.000	.000	.000	.000	.000	.000	.000	.000	.000
04	04	.000	.000	.000	.000	.000	.000	.000	.000	.000
05	04	.000	.000	.000	.000	.000	.000	.000	.000	.000
06	04	.000	.000	.000	.000	.000	.000	.000	.000	.000
01	05	.000	.000	.012	.528	.000	.000	.000	.000	.000
02	05	.000	.000	.000	.000	.000	.000	.000	.000	.000
03	05	.000	.000	.052	.000	.101	.287	.000	.000	.000
04	05	.000	.000	.000	.039	.000	.028	.000	.000	.000
05	05	.000	.000	.000	.000	.000	.000	.000	.000	.000
06	05	.000	.000	.000	.000	.000	.000	.000	.000	.000
01	06	.000	.000	.000	.000	.000	.000	.000	.000	.000
02	06	.000	.000	.000	.000	.000	.000	.000	.000	.000
03	06	.000	.000	.000	.000	.000	.000	.000	.000	.000
04	06	.000	.000	.000	.024	.000	.072	.000	.000	.000
05	06	.000	.000	.000	.000	.000	.000	.000	.000	.000
06	06	.000	.000	.000	.000	.000	.000	.000	.000	.000

C L A S S E S

		0 +	20 +	40 +	60 +	80 +	100 +	120 +	140 +	160 +
C1	01	.000	.000	[illegible]	.059	.077	.090	.085	.108	.123
C2	01	.000	.000	.000	.000	.000	.000	.000	.000	.000
C3	01	.000	.000	.009	.059	.077	.090	.086	.108	.126
C4	01	.000	.000	.081	.081	.075	.088	.084	.105	.123
C5	01	.000	.000	.081	.081	.075	.088	.084	.105	.123
C6	01	.000	.000	.296	.295	.275	.320	.307	.385	.445
C1	02	.000	.000	.052	.351	.456	.530	.509	.637	.743
C2	02	.000	.000	.241	.462	.513	.713	.685	.857	1.000
C3	02	.000	.000	.052	.351	.456	.530	.509	.637	.743
C4	02	.000	.000	.479	.479	.446	.518	.497	.662	.725
C5	02	.000	.000	.479	.479	.446	.518	.497	.662	.725
C6	02	.000	.000	.000	.000	.000	.000	.000	.000	.000
C1	03	.000	.000	.009	.062	.080	.093	.090	.112	.131
C2	03	.000	.000	.000	.000	.000	.000	.000	.000	.000
C3	03	.000	.000	.009	.062	.080	.093	.090	.112	.131
C4	03	.000	.000	.084	.084	.078	.091	.088	.110	.128
C5	03	.000	.000	.084	.084	.078	.091	.088	.110	.128
C6	03	.000	.000	.303	.303	.287	.333	.320	.400	.457
C1	04	.000	.000	.000	.000	.000	.000	.000	.000	.000
C2	04	.000	.000	.000	.000	.000	.000	.000	.000	.000
C3	04	.000	.000	.000	.000	.000	.000	.000	.000	.000
C4	04	.000	.000	.015	.015	.014	.016	.016	.020	.023
C5	04	.000	.000	.015	.015	.014	.016	.016	.020	.023
C6	04	.000	.000	.055	.055	.051	.060	.058	.072	.084
C1	05	.000	.000	.000	.000	.000	.000	.000	.000	.000
C2	05	.000	.000	.000	.000	.000	.000	.000	.000	.000
C3	05	.000	.000	.000	.000	.000	.000	.000	.000	.000
C4	05	.000	.000	.000	.000	.000	.000	.000	.000	.000
C5	05	.000	.000	.000	.000	.000	.000	.000	.000	.000
C6	05	.000	.000	.000	.000	.000	.000	.000	.000	.000
C1	06	.000	.000	.000	.000	.000	.000	.000	.000	.000
C2	06	.000	.000	.000	.000	.000	.000	.000	.000	.000
C3	06	.000	.000	.000	.000	.000	.000	.000	.000	.000
C4	06	.000	.000	.000	.000	.000	.000	.000	.000	.000
C5	06	.000	.000	.000	.000	.000	.000	.000	.000	.000
C6	06	.000	.000	.000	.000	.000	.000	.000	.000	.000

[illegible] 2 ←←←←←←←←←

[illegible]

[illegible]		AGE CLASSES 0 +	20 +	40 +	60 +	80 +	100 +	120 +	140 +	160 +
01	01	.200	.200	.200	.200	.200	.200	.200	.200	1.000
02	01	.200	.200	.200	.200	.200	.200	.200	.200	1.000
03	01	.200	.200	.200	.200	.200	.200	.200	.200	1.000
04	01	.200	.200	.200	.200	.200	.200	.200	.200	1.000
05	01	.200	.200	.200	.200	.200	.200	.200	.200	1.000
06	01	.200	.200	.200	.200	.200	.200	.200	.200	1.000
01	02	.200	.200	.200	.200	.200	.200	.200	.200	1.000
02	02	.200	.200	.200	.200	.200	.200	.200	.200	1.000
03	02	.200	.200	.200	.200	.200	.200	.200	.200	1.000
04	02	.200	.200	.200	.200	.200	.200	.200	.200	1.000
05	02	.200	.200	.200	.200	.200	.200	.200	.200	1.000
06	02	.200	.200	.200	.200	.200	.200	.200	.200	1.000
01	03	.200	.200	.200	.200	.200	.200	.200	.200	1.000
02	03	.200	.200	.200	.200	.200	.200	.200	.200	1.000
03	03	.200	.200	.200	.200	.200	.200	.200	.200	1.000
04	03	.200	.200	.200	.200	.200	.200	.200	.200	1.000
05	03	.200	.200	.200	.200	.200	.200	.200	.200	1.000
06	03	.200	.200	.200	.200	.200	.200	.200	.200	1.000
01	04	.200	.200	.200	.200	.200	.200	.200	.200	1.000
02	04	.200	.200	.200	.200	.200	.200	.200	.200	1.000
03	04	.200	.200	.200	.200	.200	.200	.200	.200	1.000
04	04	.200	.200	.200	.200	.200	.200	.200	.200	1.000
05	04	.200	.200	.200	.200	.200	.200	.200	.200	1.000
06	04	.200	.200	.200	.200	.200	.200	.200	.200	1.000
01	05	.200	.200	.200	.200	.200	.200	.200	.200	1.000
02	05	.200	.200	.200	.200	.200	.200	.200	.200	1.000
03	05	.200	.200	.200	.200	.200	.200	.200	.200	1.000
04	05	.200	.200	.200	.200	.200	.200	.200	.200	1.000
05	05	.200	.200	.200	.200	.200	.200	.200	.200	1.000
06	05	.200	.200	.200	.200	.200	.200	.200	.200	1.000
01	06	.200	.200	.200	.200	.200	.200	.200	.200	1.000
02	06	.200	.200	.200	.200	.200	.200	.200	.200	1.000
03	06	.200	.200	.200	.200	.200	.200	.200	.200	1.000
04	06	.200	.200	.200	.200	.200	.200	.200	.200	1.000
05	06	.200	.200	.200	.200	.200	.200	.200	.200	1.000
06	06	.200	.200	.200	.200	.200	.200	.200	.200	1.000

[illegible] WITH FIRE CONTROL

[illegible]		0 +	20 +	40 +	60 +	80 +	100 +	120 +	140 +	160 +
01	01	.000	.000	.000	.000	.000	.000	.000	.000	.000
02	01	.000	.000	.000	.000	.000	.000	.000	.000	.000
03	01	.000	.000	.000	.000	.000	.000	.000	.000	.000
04	01	.000	.000	.000	.000	.000	.000	.000	.000	.000
05	01	.000	.000	.000	.000	.000	.000	.000	.000	.000
06	01	.000	.000	.000	.000	.000	.000	.000	.000	.000
01	02	.000	.000	.000	.000	.000	.000	.000	.000	.000
02	02	.000	.000	.000	.000	.000	.000	.000	.000	.000
03	02	.000	.000	.000	.000	.000	.000	.000	.000	.000
04	02	.000	.000	.000	.000	.000	.000	.000	.000	.000
05	02	.000	.000	.000	.000	.000	.000	.000	.000	.000
06	02	.000	.000	.000	.000	.000	.000	.000	.000	.000
01	03	.000	.000	.000	.000	.000	.000	.000	.000	.000
02	03	.000	.000	.000	.000	.000	.000	.000	.000	.000
03	03	.000	.000	.000	.000	.000	.000	.000	.000	.000
04	03	.000	.000	.000	.000	.000	.000	.000	.000	.000
05	03	.000	.000	.000	.000	.000	.000	.000	.000	.000
06	03	.000	.000	.000	.000	.000	.000	.000	.000	.000
01	04	.000	.000	.000	.000	.000	.000	.000	.000	.000
02	04	.000	.000	.233	.260	.367	.000	.000	.000	.000
03	04	.000	.000	.000	.000	.000	.000	.000	.000	.000
04	04	.000	.000	.000	.000	.000	.000	.000	.000	.000
05	04	.000	.000	.000	.000	.000	.000	.000	.000	.000
06	04	.000	.000	.000	.000	.000	.000	.000	.000	.000
01	05	.000	.000	.012	.528	.000	.000	.000	.000	.000
02	05	.000	.030	.000	.000	.000	.000	.000	.000	.000
03	05	.000	.000	.032	.000	.101	.237	.000	.000	.000
04	05	.000	.000	.000	.039	.000	.028	.000	.000	.000
05	05	.000	.000	.000	.000	.000	.000	.000	.000	.000
06	05	.000	.000	.000	.000	.000	.000	.000	.000	.000
01	06	.000	.000	.000	.000	.000	.000	.000	.000	.000
02	06	.000	.000	.000	.000	.000	.000	.000	.000	.000
03	06	.000	.000	.000	.000	.000	.000	.000	.000	.000
04	06	.000	.000	.000	.024	.000	.072	.000	.000	.000
05	06	.000	.000	.000	.000	.000	.000	.000	.000	.000
06	06	.000	.000	.000	.000	.000	.000	.000	.000	.000

[illegible]

[illegible]		0 +	20 +	40 +	60 +	80 +	100 +	120 +	140 +	160 +
				AGE CLASSES						
01	01	.000	.000	.059	.059	.077	.090	.086	.108	.126
02	01	.000	.000	.000	.000	.000	.000	.000	.000	.000
03	01	.000	.000	.059	.059	.077	.090	.096	.108	.126
04	01	.000	.000	.061	.061	.075	.088	.084	.105	.123
05	01	.000	.000	.061	.061	.075	.088	.084	.105	.123
06	01	.000	.000	.255	.256	.275	.320	.307	.385	.449
01	02	.000	.000	.052	.351	.456	.530	.509	.537	.743
02	02	.000	.000	.241	.402	.613	.713	.685	.857	1.000
03	02	.000	.000	.052	.351	.456	.536	.509	.637	.743
04	02	.000	.000	.479	.479	.446	.518	.497	.662	.726
05	02	.000	.000	.479	.479	.446	.518	.497	.662	.726
06	02	.000	.000	.000	.000	.000	.000	.000	.000	.000
01	03	.000	.000	.009	.062	.080	.093	.090	.112	.131
02	03	.000	.000	.000	.000	.000	.000	.000	.000	.000
03	03	.000	.000	.009	.062	.080	.093	.090	.112	.131
04	03	.000	.000	.084	.084	.078	.091	.088	.110	.128
05	03	.000	.000	.084	.084	.078	.091	.088	.110	.128
06	03	.000	.000	.368	.308	.287	.333	.320	.460	.467
01	04	.000	.000	.000	.000	.000	.000	.000	.000	.000
02	04	.000	.000	.000	.000	.000	.000	.000	.000	.000
03	04	.000	.000	.000	.000	.000	.000	.000	.000	.000
04	04	.000	.000	.015	.015	.014	.016	.016	.020	.023
05	04	.000	.000	.015	.015	.014	.016	.016	.020	.023
06	04	.000	.000	.055	.055	.051	.060	.058	.072	.084
01	05	.000	.000	.000	.000	.000	.000	.000	.000	.000
02	05	.000	.000	.000	.000	.000	.000	.000	.000	.000
03	05	.000	.000	.000	.000	.000	.000	.000	.000	.000
04	05	.000	.000	.000	.000	.000	.000	.000	.000	.000
05	05	.000	.000	.000	.000	.000	.000	.000	.000	.000
06	05	.000	.000	.000	.000	.000	.000	.000	.000	.000
01	06	.000	.000	.000	.000	.000	.000	.000	.000	.000
02	06	.000	.000	.000	.000	.000	.000	.000	.000	.000
03	06	.000	.000	.000	.000	.000	.000	.000	.000	.000
04	06	.000	.000	.000	.000	.000	.000	.000	.000	.000
05	06	.000	.000	.000	.000	.000	.000	.000	.000	.000
06	06	.000	.000	.000	.000	.000	.000	.000	.000	.000

[illegible]

[illegible]	AGE CLASSES 0 +	20 +	40 +	60 +	80 +	100 +	120 +	140 +	160 +
01	.00	.00	.00	.00	1.00	1.00	1.00	1.00	1.00
02	.00	.00	.00	.00	1.00	1.00	1.00	1.00	1.00
03	.00	.00	.00	.00	1.00	1.00	1.00	1.00	1.00
04	.00	.00	.00	.00	.00	.00	1.00	1.00	1.00
05	.00	.00	.00	.00	1.00	1.00	1.00	1.00	1.00
06	.00	.00	.00	.00	.00	.00	1.00	1.00	1.00

[illegible] COEFFICIENTS [illegible]

[illegible]		AGE CLASSES 0 +	20 +	40 +	60 +	80 +	100 +	120 +	140 +	160 +
01	01	.000	.000	.125	.125	.125	.127	.126	.125	.125
02	01	.000	.000	.000	.000	.000	.000	.000	.000	.000
03	01	.000	.000	.123	.125	.125	.127	.126	.125	.126
04	01	.000	.000	.123	.123	.122	.123	.123	.117	.123
05	01	.000	.000	.123	.123	.122	.123	.123	.117	.123
06	01	.000	.000	.450	.450	.449	.449	.448	.449	.445
01	02	.000	.000	.743	.744	.744	.743	.743	.743	.743
02	02	.000	.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
03	02	.000	.000	.743	.744	.744	.743	.743	.743	.743
04	02	.000	.000	.727	.727	.725	.727	.726	.739	[illegible]
05	02	.000	.000	.727	.727	.728	.727	.726	.738	.728
06	02	.000	.000	.000	.000	.000	.000	.000	.000	.000
01	03	.000	.000	.129	.131	.131	.130	.131	.131	.131
02	03	.000	.000	.000	.000	.000	.000	.000	.000	.000
03	03	.000	.000	.129	.131	.131	.130	.131	.131	.131
04	03	.000	.000	.127	.127	.127	.128	.128	.123	.128
05	03	.000	.000	.127	.127	.127	.128	.128	.123	.128
06	03	.000	.000	.457	.467	.468	.457	.467	.457	.467
01	04	.000	.000	.000	.000	.000	.000	.000	.000	.000
02	04	.000	.000	.000	.000	.000	.000	.000	.000	.000
03	04	.000	.000	.000	.000	.000	.000	.000	.000	.000
04	04	.000	.000	.023	.023	.023	.022	.023	.022	.023
05	04	.000	.000	.023	.023	.023	.022	.023	.022	.023
06	04	.000	.000	.063	.065	.063	.084	.065	.084	.084
01	05	.000	.000	.000	.000	.000	.000	.000	.000	.000
02	05	.000	.000	.000	.000	.000	.000	.000	.000	.000
03	05	.000	.000	.000	.000	.000	.000	.000	.000	.000
04	05	.000	.000	.000	.000	.000	.000	.000	.000	.000
05	05	.000	.000	.000	.000	.000	.000	.000	.000	.000
06	05	.000	.000	.000	.000	.000	.000	.000	.000	.000
01	06	.000	.000	.000	.000	.000	.000	.000	.000	.000
02	06	.000	.000	.000	.000	.000	.000	.000	.000	.000
03	06	.000	.000	.000	.000	.000	.000	.000	.000	.000
04	06	.000	.000	.000	.000	.000	.000	.000	.000	.000
05	06	.000	.000	.000	.000	.000	.000	.000	.000	.000
06	06	.000	.000	.000	.000	.000	.000	.000	.000	.000

[illegible]

[illegible]	G1	G2	G3	G4	G5	G6	[illegible]	TOTAL
0	10.72	55.[illegible]	11.74	11.96	4.[illegible]	.73	.00	10000.00
1	10.01	61.14	11.43	12.02	4.55	.40	.00	10000.00
5	7.11	[illegible].04	8.39	12.[illegible]	[illegible].67	.41	.00	10000.00
10	6.55	59.[illegible]	7.55	13.40	2.16	.47	.00	10000.00
15	[illegible].52	[illegible]	7.62	13.57	2.13	.47	.00	10000.00
20	[illegible].52	60.6[illegible]	7.62	13.57	2.14	.47	.00	10000.00
25	[illegible].37	73.02	5.72	13.10	.54	.25	552.15	10000.00

[illegible]

[illegible]	0 +	20 +	40 +	60 +	80 +	100 +	120 +	140 +	160 +	TOTAL
0	2463.00	2386.00	2331.00	1872.00	761.00	195.00	18.00	.00	.00	10000.00
1	2051.54	2465.00	2380.00	1860.20	552.54	271.25	55.57	5.07	.00	[illegible]
5	2235.[illegible]	2313.03	2365.00	1767.12	805.62	372.31	102.43	31.51	[illegible]	[illegible]
10	2270.22	2274.57	2300.15	1750.90	880.35	346.30	101.35	32.[illegible]7	3.47	[illegible]
15	2260.24	2275.67	2281.50	1783.08	895.85	345.34	55.35	31.04	3.32	10000.00
20	2281.35	2280.62	2280.47	1775.22	897.15	346.85	55.45	31.[illegible]	3.[illegible]	10000.00
25	2520.90	2400.99	2337.71	1910.96	641.04	158.18	11.22	.00	.00	10000.00

[illegible]

[illegible]	0 +	20 +	40 +	60 +	80 +	100 +	120 +	140 +	160 +	TOTAL
0	24.63	23.86	23.31	18.72	7.01	1.95	.18	.00	.00	100.00
1	20.51	24.63	23.80	18.00	9.53	2.71	.56	.05	.00	100.00
5	22.38	23.13	23.00	17.67	8.10	3.73	1.0[illegible]	.32	.04	100.00
10	22.70	22.75	23.00	17.51	8.80	3.46	1.01	.33	.03	100.00
15	22.60	22.76	22.82	17.83	8.97	3.45	.93	.32	.04	100.00
20	22.81	22.81	22.80	17.75	8.97	3.47	.95	.31	.04	100.00
25	25.21	24.10	23.38	19.11	6.41	1.58	.11	.00	.00	100.00

[illegible]

[illegible]	01	02	03	04	05	06	[illegible]	TOTAL
0	.00	.00	.00	.00	.00	.00	.00	.00
1	.00	.00	.00	.00	.00	.00	.00	.00
5	.00	.00	.00	.00	.00	.00	.00	.00
10	.00	.00	.00	.00	.00	.00	.00	.00
15	.00	.00	.00	.00	.00	.00	.00	.00
20	.00	.00	.00	.00	.00	.00	.00	.00
25	.00	56.54	14.75	4.03	21.72	2.03	500.00	500.00

[illegible]

[illegible]

[illegible]	0 +	20 +	40 +	60 +	80 +	100 +	120 +	140 +	160 +	TOTAL
0	300.00	251.00	275.00	215.00	.00	.00	.00	.00	.00	1072.00
1	167.70	300.00	281.00	252.45	.00	.00	.00	.00	.00	1001.15
5	150.01	154.44	151.56	155.29	.00	.00	.00	.00	.00	716.51
10	165.70	167.12	159.23	153.02	.00	.00	.00	.00	.00	555.74
15	166.20	166.26	166.65	153.07	.00	.00	.00	.00	.00	652.18
20	156.35	155.32	166.36	152.80	.00	.00	.00	.00	.00	651.83
25	164.75	154.30	157.73	160.12	.00	.00	.00	.00	.00	635.94

[illegible]	0 +	20 +	40 +	60 +	80 +	100 +	120 +	140 +	160 +	[illegible]
0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.00	.00	.00	.00	[illegible]
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.00	.00	.00	.00	[illegible]
5	[illegible]	1911.37	1947.[illegible]	[illegible]	271.[illegible]	.00	.00	.00	.00	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	304.[illegible]	.00	.00	.00	.00	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.00	.00	.00	.00	[illegible]
20	[illegible]	1915.[illegible]	[illegible]	[illegible]	[illegible]	.00	.00	.00	.00	[illegible]
25	[illegible]	2072.[illegible]	[illegible]	[illegible]	[illegible]	.00	.00	.00	.00	[illegible]

[illegible]	0 +	20 +	40 +	60 +	80 +	100 +	120 +	140 +	160 +	[illegible]
0	303.00	251.00	235.00	232.00	63.00	.00	.00	.00	.00	[illegible]
1	174.[illegible]	303.00	251.00	[illegible]	122.50	13.02	.00	.00	.00	[illegible]
5	175.[illegible]	[illegible]	[illegible]	[illegible]	77.11	38.34	.00	.00	.00	[illegible]
10	172.17	173.7[illegible]	175.[illegible]	145.74	75.75	22.20	.00	.00	.00	[illegible]
15	172.[illegible]	172.74	173.1[illegible]	145.1[illegible]	75.51	21.7[illegible]	.00	.00	.00	[illegible]
20	172.[illegible]	172.[illegible]	[illegible]	[illegible]	[illegible]	21.65	.00	.00	.00	[illegible]
25	171.[illegible]	166.39	[illegible]	151.[illegible]	25.51	.00	.00	.00	.00	[illegible]

[illegible]	0 +	20 +	40 +	60 +	80 +	100 +	120 +	140 +	160 +	[illegible]
0	54.00	52.00	51.00	450.00	379.00	[illegible]	13.00	.00	.00	[illegible]
1	[illegible]	54.00	52.00	479.72	352.42	200.47	[illegible]	4.10	.00	[illegible]
5	[illegible]	[illegible]	25.71	[illegible]	343.41	[illegible]	43.74	[illegible]	[illegible]	[illegible]
10	[illegible]	25.51	25.55	[illegible]	385.55	[illegible]	50.43	[illegible]	1.[illegible]	[illegible]
15	[illegible]	[illegible]	25.60	552.52	[illegible]	209.00	[illegible]	[illegible]	1.[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	551.1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.[illegible]	[illegible]
25	24.12	[illegible]	[illegible]	[illegible]	474.04	[illegible]	7.53	.00	.00	[illegible]

[illegible]	AGE CLASSES									
	0 +	20 +	40 +	60 +	80 +	100 +	120 +	140 +	160 +	TOTAL
0	110.00	100.00	134.00	52.00	50.00	.00	.00	.00	.00	[illegible]
1	.00	110.00	100.00	64.50	106.55	44.25	4.51	.00	.00	460.15
5	.00	.00	.00	19.57	106.55	55.55	40.55	12.34	1.24	[illegible]
10	.00	.00	.00	16.01	107.15	45.39	26.04	[illegible]	.25	[illegible]
15	.00	.00	.00	17.44	103.05	49.40	26.13	[illegible]	.57	216.41
20	.00	.00	.00	17.91	[illegible]	49.57	28.00	[illegible]	.31	215.57
25	.00	.00	.00	16.77	25.39	.00	.00	.00	.00	94.11

[illegible]	AGE CLASSES									
	0 +	20 +	40 +	60 +	80 +	100 +	120 +	140 +	160 +	TOTAL
0	.00	.00	.00	16.00	22.00	33.00	5.00	.00	.00	76.00
1	.00	.00	.00	.00	17.22	8.51	21.13	1.50	.00	48.44
5	.00	.00	.00	.00	11.04	4.56	16.13	5.59	.51	45.55
10	.00	.00	.00	.00	13.08	4.52	25.46	6.70	.52	46.55
15	.00	.00	.00	.00	13.24	5.05	20.35	6.54	.55	46.77
20	.00	.00	.00	.00	13.23	5.12	20.91	5.55	.55	[illegible]
25	.00	.00	.00	.00	15.06	5.12	3.35	.00	.00	24.57

****

APPENDIX 12

NOTES ON ESTIMATING PREVIOUS FOREST AGE DISTRIBUTIONS

1. Rationale

Assuming that the 20 year mean rate of disturbance, prior to fire control, was relatively constant, one would expect the age distribution of the forest at that time to follow a negative exponential decay curve,

$$N_t = N_o e^{-rt}$$

where,

N_t = area of forest of age t

N_o = area of forest in the youngest age class

r = rate of stands with respect to age

e = base of the natural logarithm

Although the general form of the equation, with r defined as some constant, gives a rough estimate of the age distribution prior to fire control, the resultant curve may be improved by changing the value of r for each age class. Since younger forests are known to be generally less susceptible to disturbance than older forests, due to the build-up of litter and dead wood as a stand matures, it seems valid to introduce larger values for r in calculating older age classes.

This approach was adopted in estimating the 1917-1937 forest age distribution of upland and lowland areas. Disturbance was presumed to be negligible until age 40 for upland stands (based on field observation), and age 80 for lowland forest. Beyond these age classes,

disturbance rates are thought to increase rapidly and then level off. This observed levelling of the curve (Fig. 4.2) probably represents a few stand on islands and promontaries in lakes which are rarely reached by fires.

By substituting increasing values for r in the equation above, several possible distributions were readily produced.

2. Testing Previous Age Distributions

Having developed several plausible age distributions for the period prior to fire control, it was necessary to simulate the development of these towards the present using reduced disturbance rates (due to recent fire control) in order to make estimates of the present age distribution.

Following careful screening of each test distribution, those that most closely estimated the present observed distributions for upland and lowland forest, were selected as input distributions for the main simulation model.

3. Running the Simulation Forward

Given a current stable (i.e., unchanging)age distribution and total disturbance values for the forthcoming years, one can estimate the age distribution at some future date.

For example, starting with the following distribution and a known overall disturbance of 168 ac,the distribution may be estimated for time t + 1 as follows:

Age Class (years)	0-19	20-39	40-59	60-79	80-89
Age specific disturbance coefficient (D)	0.434*	0.653	0.879	1.0	
Area (ac.) (A)	168	95	33	4	0

$$* \frac{168 - 95}{168} = 0.434$$

The total disturbance in the next time period will be:

$$\sum [D.F.A.]$$

where,

F is a factor by which the old disturbance coefficient must be multiplied to give the new disturbance rate. Effectively it is the fire control coefficient.

If the new rate of disturbance is 111 acres, the equation is solved as follows:

$$111 = (168 \times 0.434\ F) + (95 \times 0.653F) + (33 \times 0.879\ F) + (4 \times 1.0\ F)$$

Therefore F = 0.661

The current coefficients are multiplied by F to give their new equivalents:

e.g., $0.434 \times 0.661 = 0.287$

And thus the new age distribution is:

Age Class	0-19	20-39	40-59	60-79	80-89
Age specific disturbance coefficient (D)	0.287	0.432	0.581	0.661	1.0
Area (ac.) (A)	111	120	54	14	1

When the total disturbance increases rather than decreases, one may have to solve for x by iteration.

As an example, suppose one begins with the same distribution but observes an increase in total disturbance to 180 acres. In this case the solution is:

$$(168 \times 0.434\,F) + (95 \times 0.653\,F) + (33 \times 0.879\,F) + (4 \times 1.0\,F) = 180$$

Therefore, $F = 1.0717$

However, substituting 1.07 for F in the expression $(4 \times 1.0x)$ would result in a value which is greater than 4, the amount available for disturbance. Since one cannot destroy more area than is available, it is obvious that x times the disturbance coefficient must not exceed 1.0. If it does, the product is set to 1.0 and the process above is repeated. By calculating the reciprocal of all disturbance coefficients beforehand, one can easily see if the solution for F exceeds any of these values.

In the example $F \times 4.0 > 4$ one simply substitutes the maximum possible for this term (4), then resolves:

$$(168 \times 0.434\,F) + (95 \times 0.653\,F) + (33 \times 0.879\,F) + 4 = 180$$

$$x = 1.0734$$

Then, by multiplying the age specific disturbance coefficients by this value one may calculate the new distribution.

Age Class	0-19	20-39	40-59	60-79
Age specific disturbance coefficient (D)	0.466	0.701	0.944	1.0
Area (ac.) (A)	180	90	28	2

APPENDIX 13

WRITTEN RESPONSES OF TRAPPERS

LOGGING OF NORTHERN FOREST, - DAMAGE DONE

Written addendum to questionnaire submitted by W. Wingenroth, trapper

The damage done to the forest environment by modern logging methods is irreparable within a person's lifetime. Also there is no intent by either the government or the forest products companies to even attempt to repair this damage and to restore the forest to its former state. Rather their aim is to remove any area that has been cut over from the natural forest biome and to instate an artificial "silviculture" type of forest, with exclusive planting in rows, or aerial seeding of "superior type" conifers. Deciduous trees are then repressed by use of mechanical (rare) and chemical (common) methods.

This means, that after logging, the northern forest is effectively removed from any other human land use (except mining) for a person's liftime, and infinality altered to the degree, that any such land use is still in question.

For wildlife the change is equaly drastic, in that after logging, which is done exclusively in clearcut fashion, the habitat is removed, and in that future silvicultural methods make the resulting habitat unsuitable for many species.

"Trees are renewable - wilderness is not".

How this affects me as a trapper

As habitat dwindles, so does the supply of furbearers. Building of roads, clearcuts, bridges, gravel pits, dumps, logging camps, all these interfer seriously with the furbearers' lives as well as with the trapper's carrying out his task. Areas cut not only deprive the trapper of furbearers that could have lived in these areas but also reduce to nil his investment in form of cabins, built trails, even mobile equipment such as traps, canoes, snowmobiles. In addition roads draw the public which is prone to steal or do damage to the trapper's installation, also to pollution, littering, poaching and quite seriously-needless destruction of furbearers.

Further environmental damage can be caused through excessive soil erosion, which will silt up small lakes and damage the water ecology, alternating floods and droughts which make even small lake and creek areas unsuitable habitat for aquatic species. Like beaver, mink, muskrat, otter.

The destruction by modern logging is accelerated to such a degree that correspondingly necessary research is lagging far behind. It would be imperative to halt or slow down these processes long enough to give researchers pause in which they can try to research, evaluate and understand fully the effects of logging on the whole northern environment. The course that is followed by the government at this time is clearly a shortsighted, irresponsible one. One that gives the forest industry the first consideration, while every other interest rates 3rd.

Trapping, by the way, seems to be rated 4th. We often feel that the prov. government would be happy to just see it "go away".

DECEMBER 27/79
SAVANT LAKE ,ONT.

THE CONCERNED TRAPPERS OF SAVANT LAKE AND SURROUNDING AREA :

(like to ask for the following rights,privileges,changes, verifications,like to make known the following complaints, whatever the case may be:)

"To enable to carry a gun on trapline,for protection,for survival.A trapper to be able to kill a moose for food.
To be able to use a net,to fish for food or bait.Also to feed dogs.
The trappers to be able to build cabins for themselves,and to cut trees for themselves.Why is it that we can't now?
Mary Necan had to pay for every log she used for her cabin on her trapline.

Game wardens are interfering with our traps,checking up on them. When they come upon animals in traps they kill the animals, hit them,leave them and then they get eaten,damaged.Are the game wardens allowed to check traps like that?

Great lakes cutting:
Great lakes should at least leave about four hundred feet from lakes or any small area of lake,as beavers need green bush for feeding.We find, that on lakes that are cut to the shore the beavers just leave the area,and have to perish.
Not only beavers are gone when the area is destroyed,but also moose and other animals.
When big machines come through the bush and close to the lakes of cutting areas,they never know how many birds and small animals they kill,mostly in the spring,when the birds and animals are young.
Also lots of oil from the big machines drip into the lakes.
The beavers and other water animals hate oil.

over

When trees are replanted it takes such a long time for them to grow. Then, when the bushes and other plants grow, the next thing they use on these are chemicals, which is the worst they have ever done, since the animals have to eat those plants.
The brush and plants of all sorts should be left to grow.

Trapline maps should be issued yearly, so we know when borders are being changed.

The beaver quota is too low for some trappers. These trappers like to ask for more beavers."

Copies to the following:

Royal Commission on the Northern Environment
Ontario Trappers Ascn
Roger Suffling, Assistant Professor,
Faculty of Environmental Studies
University of Waterloo

WAWATA

Minutes of Meeting Held with Savant Lake Trappers - March 10, 1980

A meeting was held at the Four Winds Motel in Savant on March 10, 1980 to address the concerns of the local trappers relative to a petition signed by fourteen of the trappers. In attendance on behalf of the Ministry of Natural Resources was Art Martin, Fish and Wildlife Supervisor and Mike Eliuk, Wildlife Management Officer. There were 21 trappers present and two reporters for the Wa Wa Ta newspaper. Garnet Angeconeb acted as interpreter and Ed Mishi-metic acted as spokesman for the trappers.

Each of the questions and concerns expressed in the petition of December 27, 1979 were addressed individually. The following is a summary of comments made regarding the questions contained in the petition:

1. Trappers are allowed to carry guns on their trap-lines except in any area closed for the safety of other bush users.
2. Treaty Indians for Treaty Area # 9 are allowed to kill moose throughout the year within their treaty area for their own consumption. Trappers that are not treaty Indians are entitled to shoot one moose during the open season for moose provided he has purchased a valid moose hunting licence.
3. Trappers are not allowed to use a gill net to take fish. Treaty Indians, however may take fish for personal consumption after first obtaining a special permit.
4. Trappers are allowed to build a specified number of cabins on their trap-lines. Construction of cabins must be approved by the MNR in advance. No charge is made for the logs.
   - No record can be found in the Sioux Lookout office of Mary Necan paying for logs she used in trap-line cabin construction.
5. The people referred to as game wardens interferring with set traps were not, in fact, game wardens. The meeting was informed that all persons driving MNR trucks are not game wardens. It was strongly suggested that when trappers are approached by individuals professing to be game wardens, that they demand identification.
6. Shoreline cutting - it was stressed that in some instances shoreline cutting can be beneficial to fur bearers. In all cases the MNR has control over cutting done by the large companies and we would monitor the cuts closely so that the concerns of the trappers are recognized.
7. Any time there is any change in trapping areas the trappers are the first to know about it and will receive revised maps.
8. Beaver quotas in unsurveyed trap-lines are a reflection of past production. On surveyed lines the quotas are arrived at by multiplying the number of live beaver houses by the factor 1.5. If the trapper indicates that there has been an influx of beaver on to his line then the quota can be arbitrarily increased.

The following trappers support this price by their signatures:

Signatures

George Belmore

Mr + Mrs M. Necan

David Necan

Jane Necan

x Isabelle Maggalte

Gladys Ombash

Donald Ombash

A. Joseph

Marie Joseph

Mary Joseph

E. Joseph

Gilbert Joseph

Sarah Belmore

Violet Joseph

more signatures to follow